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Aeronautical Engineering REVIEW

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JULY, 1954

How the Holley Turbine Control helps jet pilots concentrate on FIGHTING, not flying

Nearly every foot of altitude, gained or lost, nearly every minute change in atmospheric conditions alters the amount of fuel flow needed by today's jet engine. Literally hundreds of mathematical problems must be solved every minute a jet is in the air. It would be impossible for any pilot to solve all these problems and still have time to concentrate on fighting. So the Holley Turbine Control was developed to solve them for him AUTOMATICALLY.

Holley's research department played an important role in the development of this mechanical wizard. But producing Holley Turbine Controls requires special skills, too. Working to tolerances of as little as plus or minus 25 millionths of an inch, the Holley manufacturing division turns out turbine controls for thousands of today's jet aircraft.

Holley's highly-trained research, engineering and manufacturing staff can support your program of producing better products for the aviation industry, either your design or ours.

Leader in the design, development, and manufacture of aviation fuel metering devices.

HOLLEY Carburetor Co.

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Aeronautical Engineering Review

Vol. 13—No. 7 July, 1954

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Cover—Rows of completed tail assemblies and control surfaces are shown in the final assembly line at The Glenn L. Martin Company as they await their turn to become a part of the B-57, a light bomber built for the Air Force by Martin. The human figure in the background gives a rough idea of the size of these B-57 tail assemblies and control surfaces.

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Rohr builds more power packages for airplanes than any other company in the world — and this picture shows the Rohr-built power packages on the wing of the big, beautiful Lockheed Super Constellation. In addition to producing power packages for the world's leading commercial and military planes, Rohr Aircraftsmen are currently making more than 25,000 different parts for all types of aircraft.

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IAS News

A Record of People and Events of Interest to Institute Members

Turbine-Powered Air Transportation Meeting

Meeting to Be Held August 9 to 11 in Seattle. Program to Include Field Trip to Boeing. United Aircraft Executive to Be Principal Dinner Speaker.

THE INSTITUTE OF THE AERONAUTICAL SCIENCES's forthcoming national meeting on "Turbine-Powered Air Transportation" will be held at the Benjamin Franklin Hotel in Seattle, Wash., from Monday, August 9, through Wednesday, August 11. Plans for this meeting have been made through the cooperation of the IAS Seattle Section, the IAS Arrangements Committee chairmanned by G. W. Taylor, and Boeing Airplane Company.

The program for this 3-day meeting consists of five technical sessions, two luncheons, a dinner, and a field trip. The technical sessions have been so arranged that there will be two on Monday, two on Tuesday, and one on Wednesday morning. The field trip, which will be to Boeing's Seattle plant, will get under way immediately after the Wednesday morning session.

The dinner and the two luncheons will take place in the Cascade Room of the Benjamin Franklin Hotel. The dinner will be held there on Tuesday evening at 7:00 p.m., and the principal speaker will be Leonard S. Hobbs, Vice-President—Engineering, United Aircraft Corporation. J. L. Atwood, IAS President and President of North American Aviation, Inc., will act as toastmaster.

The Monday and Tuesday sessions will meet from 9:00 a.m. to 12:00 noon and from 2:00 to 5:00 p.m. The Wednesday session will begin at 9:00 a.m. and will be concluded at 11:30 a.m. The papers to be presented at these five sessions are as follows:

▸ **Monday, August 9**—*Morning Session* (Chairman, S. Scott-Hall, Head, Technical Services, British Joint Services Mission): "Air-Line Turbine Transport Considerations" by M. G. Beard, Assistant Vice-President—Equipment Development, American Airlines, Inc.; "Turbine-Powered Transports" by Gen. Joseph Smith, Commanding General, MATS; and "Some Design Considerations in the Development of the Douglas Model YC-124B Turboprop Transport" by Donald L. Elder, Douglas Aircraft Company, Inc. *Afternoon Session* (Chairman, unknown at press time): "Long-Range Propeller-Turbine-Engined Transports" by Dr. W. J. Strang, Chief Aerodynamicist, Aircraft Division, Bristol Aeroplane Company, Ltd.; "Some Performance Considerations of a Jet Transport Airplane" by G. S. Schairer, Chief of Technical Staff, Boeing, and M. Lynn Olason, Aerodynamics Unit, Boeing; and "Turboprop Engine Application Problems" by Philip Colman, Chief Preliminary Design Engineer, Lockheed Aircraft Corporation.

▸ **Tuesday, August 10**—*Morning Session* (Chairman, E. S. Thompson, General Electric Company): "Turbine Engines for Transport Airplanes" by Abe Silverstein, Associate Director, Lewis Flight Propulsion Laboratory, NACA; "Operational Characteristics of Turboprop Propellers" by George W. Brady, Director of Engineering, Propeller Division, Curtiss-Wright Corporation; and "Selection of Fuels for Commercial Turbine-Powered Aircraft" by C. R. Johnson, E. R. Kennedy, and W. S. Little, Shell Oil Company. *Afternoon Session* (Chairman, unknown at press time): "Comet Operations" by A. C. Campbell Orde, Operations Development Director, British Overseas Airways Corporation; "Economics of Turbine Transport Operation" by R. D. Kelly, Superintendent, Technical Development, United Air Lines, Inc., and Lester G. Kelso, United; "The CAA and Turbine-Powered Transportation" by F. B. Lee, Administrator, CAA; and "Stopping Large Jet Airplanes" by J. E. Steiner, Project Engineer, Preliminary Design, Boeing.

▸ **Wednesday, August 11**—*Morning Session* (Chairman, E. C. Wells, Vice-President—Engineering, Boeing): "Water Basing the Jet Transport" by Marvin I. Haar, Stevens Institute of Technology; and "Design Considerations of the Boeing Model 707" by M. L. Pennell, Chief Project Engineer, Boeing.

As soon as the Wednesday morning session is finished, those persons who are participating in the field trip to the Boeing Seattle plant will be transported from the hotel to the plant. Members of the field trip will be served luncheon in the plant cafeteria as guests of the company. During the afternoon, there will be a tour of the plant and an inspection of turbine-powered aircraft, including Boeing's new jet tanker-transport prototype.

Special arrangements will be required for any person who is not a United States citizen and who wishes to participate in the Boeing field trip. In order to expedite such arrangements, it is requested that citizens of foreign countries desiring to visit the Boeing plant at this time so indicate in a letter addressed to G. W. Taylor, Sales Division, Boeing Airplane Company, Seattle. This letter should contain the following information: country of citizenship, company affiliation, and title or position with that company.

IAS members will receive copies of the final program through the mails.

Second Southwestern Student Competition

Major C. E. (Chuck) Yeager, USAF, Principal Speaker at Awards Dinner

The Second Southwestern Student Competition, conducted by the Texas Section of the Institute of the Aeronautical Sciences, was held in Dallas, Tex., on April 21–24 with headquarters at the Adolphus Hotel. During this time, 24 graduate and undergraduate students from 14 colleges delivered original papers on aeronautical subjects. The cost of the conference, including the prize money and travel expenses for the participants, was underwritten by a group of four Texas aircraft companies—Bell Aircraft Corporation, Chance Vought Aircraft, Inc., Consolidated Vultee Aircraft Corporation, and Temco Aircraft Corporation.

On Wednesday evening, April 21, the students and accompanying faculty were welcomed by Douglas G. Andreoli, Texas Section Chairman. A review of the aircraft company activities in the Dallas-Fort Worth area was presented in the form of movies by each of the four sponsoring companies.

On Thursday, the competition formally got underway with the presentation of papers on Aerodynamics and Propulsion by the graduate students and of papers on Propulsion and Design by the undergraduate students. The following day was devoted to undergraduate sessions, which were attended by the Senior Aeronautical Engineering Class from the University of Texas. Papers on Aerodynamics and Performance were delivered in the Friday morning sessions; papers on Structures and Loads were given in the afternoon sessions.

Luncheons were held on both Thursday and Friday. At these functions, the students, faculty, and guests heard the top engineering and management executives of the sponsoring aircraft companies present reviews of company growth and organization as well as views on the requirements for good engineers.

On Thursday, F. N. Dickerman, Chief Engineer, Chance Vought Aircraft, Inc., and H. Gaylord, Vice-President, Bell Aircraft Corporation, were the speakers. Mr. Dickerman spoke about "People Who Can't Say No," meaning those persons who, instead of saying that something is impossible or can't be done, go ahead and give it a good try. He concluded his talk with a brief history of Chance Vought, beginning with the VE-7 biplane of 1917 and ending with the latest XF8U-1 Navy day fighter. Mr. Gaylord reviewed the background of his company and touched upon its work in the experimental aircraft field and in helicopter production. Mr. Gaylord heads the Bell Helicopter Division.

The Friday luncheon speakers were A. C. Esenwein, Vice-President, Convair, and R. McCulloch, President, Temco Aircraft Corporation. Mr. Esenwein outlined the organizational arrangement of the overall corporation and followed with specific points about the Fort Worth Division. He said that planned production for the future includes a supersonic bomber currently in the development stages. Mr. McCulloch gave a brief résumé of his company's organization and history. He told of the various products put out by Temco in its early days and stated that presently the company's major effort is based upon the overhaul of commercial and military planes and subcontracting of major assemblies.

Thursday evening was taken up with a barbecue held at White Rock Lake. On the following evening, the students were entertained with the film, *We Saw It Happen*, produced by United Aircraft Corporation. At the same time this film was being shown, members of the industry and faculty met to discuss ways and means of improving future competitions and the various problems associated with training engineers for the aircraft industry.

Bell, Chance Vought, Convair, and Temco were hosts to the students and faculty members for inspection trips through their facilities. This was on Saturday, and the group traveled by bus from Dallas to Hurst, Fort Worth, and Grand Prairie and back to Dallas. Luncheon was served by Chance Vought.

On Saturday evening, 300 members of the Texas Section and their guests together with the students and faculty members gathered at the Roof Garden of the Adolphus Hotel for the Awards Night Dinner. Following dinner, Chairman Andreoli welcomed the group and introduced the honored guests. These included: R. R. Dexter, IAS Secretary; H. Gaylord, Vice-President, Bell Aircraft; B. Kelly, Chief Engineer, Helicopter Division, Bell Aircraft; Capt. C. M. Jett, USN, BAR, Dallas; F. O. Detweiler, President, Chance Vought; F. N. Dickerman, Chief Engineer, Chance Vought; A. C. Esenwein, Vice-President, Convair; Lt. Col. C. Savage, USAF, AFPR, Fort Worth; J. W. Larson, an IAS Vice-President and Chief Engineer, Convair, Fort Worth; R. McCulloch, President, Temco; and H. G. Erickson, Director of Engineering, Temco.

The Chairman then introduced J. L. Atwood, IAS President and President,

The students and faculty attending the Texas Section's Second Southwestern Student Competition are shown at the Awards Night Dinner. This event brought the 4-day competition to a close.

North American Aviation, Inc. Mr. Atwood spoke briefly on "A Sense of Responsibility," an important and desirable quality, he said, often found lacking in engineers.

The principal speaker was Major C. E. (Chuck) Yeager, USAF, who gave the audience a graphic account of how it feels to fly through the sonic barrier. The USAF Test Pilot told how modern research planes are being used in test flying. Much of his talk, however, centered around the X-1 which he flew faster than sound in 1947. Major Yeager said that the X-1 attained supersonic speed at a 40,000-ft. altitude and that the X-1A, which he piloted at about 1,600 m.p.h. last December 12, reached that speed at an altitude of approximately 78,000 ft.

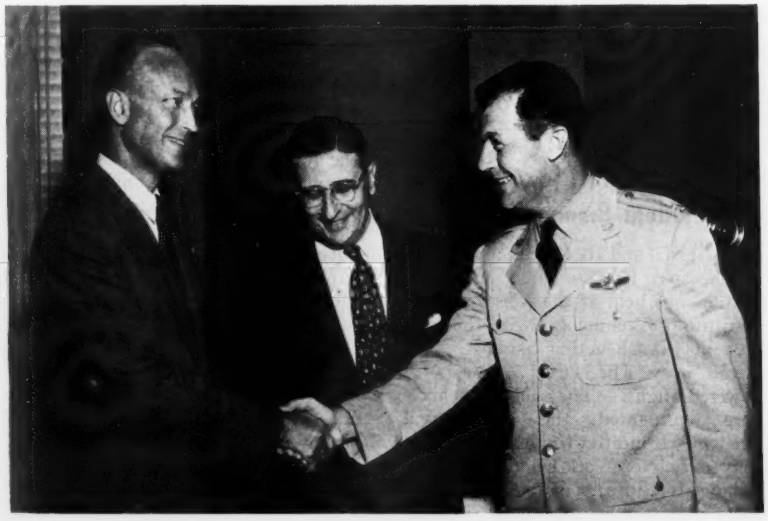
The climax of the 4-day event was the presentation of awards by IAS President Atwood to the six student winners. The winners in the competition's Undergraduate Division and their papers were: *First Prize*, Kelly W. Thurston, University of Utah, "Design and Characteristics of a Rotating Combustion Chamber Engine;" *Second Prize*, Kenneth G. Wernicke, University of Kansas, "A Determination of the Boundary Layer Temperature Recovery Factor on a Flat Plate in Supersonic Flow;" and *Third Prize*, Richard L. Schapker, Parks College, St. Louis University, "Turbojet Compressor with Counterrotating Element." The winners in the Graduate Division were: *First Prize*, Charles M. Halsell, University of Texas, "Design of a Semi-Flexible Variable Mach Number Nozzle;" *Second Prize*, Charles L. Wharton, Georgia Institute of Technology, "Effects of Screens in Wide Angle Diffusers of Square Cross Section;" and *Third Prize*, Lawrence R. Selkirk, University of Oklahoma, "A Method of Estimating Jet Engine Performance."

The winners of the Texas Section's Second Southwestern Student Competition are shown with Douglas G. Andreoli, Texas Section Chairman, and J. L. Atwood, IAS President and President of North American Aviation, Inc. From *left to right* are R. L. Schapker, Third Prize Winner, Undergraduate Division, Parks College, St. Louis University; K. G. Wernicke, Second Prize Winner, Undergraduate Division, University of Kansas; K. W. Thurston, First Prize Winner, Undergraduate Division, University of Utah; Mr. Andreoli; Mr. Atwood; C. M. Halsell, First Prize Winner, Graduate Division, University of Texas; and C. L. Wharton, Second Prize Winner, Graduate Division, Georgia Institute of Technology. Not shown in this photograph is L. R. Selkirk, Third Prize Winner, Graduate Division, University of Oklahoma.

The Second Southwestern Student Competition was then closed with a resolution of thanks to the Texas Section, the IAS, and the supporting companies. This was submitted by A. E. Cronk, of the University of Minnesota, as spokesman for the faculty representatives.

B. KOHR
Publicity Chairman
Texas Section

Shown from *left to right* are: J. L. Atwood, IAS President and President of North American Aviation, Inc.; Douglas G. Andreoli, Chairman of the Texas Section; and Major C. E. Yeager, USAF, Principal Dinner Speaker. This photograph was taken at the Awards Night Dinner that concluded the 4-day Second Southwestern Student Competition.



Guggenheim Fellowships Awarded at CalTech

The appointment of two new Guggenheim Jet Propulsion Fellows and the renewal of Fellowships for three others at the California Institute of Technology was announced on May 10 by Harry F. Guggenheim, IAS Member, Honorary Member, and Benefactor, President of The Daniel and Florence Guggenheim Foundation, and Dr. L. A. DuBridge, President of CalTech.

The new Fellows who were selected to carry programs of advanced study and research at CalTech's Daniel and Florence Guggenheim Jet Propulsion Center are: Jack L. Kerrebrock and Sedat Serdengecti, both students at CalTech.

Those Fellows whose grants have been renewed for an additional year are: David M. Benenson, Saul Feldman, and Robert J. Hartlieb, Jr., TMIAS. Messrs. Benenson and Feldman are IAS Student Members.

The Daniel and Florence Guggenheim Jet Propulsion Center at CalTech was established in 1948 by the Guggenheim Foundation to provide facilities for graduate education and research in jet propulsion and rocket engineering with particular emphasis on peacetime uses. The principal post at the CalTech Jet Propulsion Center is the Robert H. Goddard Professorship, named in honor of the American rocket pioneer, Dr. Robert H. Goddard (1882–1945). This post is held by Dr. H. S. Tsien, FIAS.

Musick Memorial Trophy Awarded to Sir Melvill Jones

Sir Bennett Melvill Jones was awarded the Musick Memorial Trophy this spring by the Royal Aeronautical Society on behalf of the Royal New Zealand Aero Club. Sir Melvill Jones was cited "for his work over a long period of years, wherein he contributed so much to the safety of flying and the development of aircraft." He is an Honorary Fellow of the Royal Aeronautical Society and the Institute of the Aeronautical Sciences.

Sir Melvill Jones, who was knighted in 1942 for his services to aircraft development, has been associated with aeronautical research since 1910. His findings in this field have had considerable influence in both aeronautical research and aviation.

In 1910, shortly after his graduation from Emmanuel College, Cambridge University (Mechanical Science Tripos, 1909), Sir Melvill Jones joined the staff of Great Britain's National Physical Laboratory and undertook the design of some early British wind tunnels and the development of certain experimental techniques and theoretical studies of stability and control. In 1914, after a year as an Airship Designer with Sir W. G. Armstrong Whitworth & Company, Ltd., he became engaged in model and full-scale aerodynamic research for the Royal Aircraft Factory. Two years later, at the Armament Experimental Station, Orfordness, he conducted experimental studies of aerial navigation, blind flying, bomb- and gun-sight operation, and the training necessary for these purposes. In 1918 and 1919, he served as Deputy Director of Britain's Research Air Ministry. In 1919, he was named the Francis Mond Professor of Aeronautical Engineering at Cambridge University, thus becoming the first Professor of Aeronautics in England. He remained in this professorial appointment until 1952. He is now acting as Consultant to the Royal Aircraft Establishment.

Some of the experimentation that he carried out at Cambridge was the basis of a paper presented by him on December 17, 1937, before the Institute of the Aeronautical Sciences as that group's first Wright Brothers Lecturer. His paper in this instance was entitled "Flight Experiments on the Boundary Layer" and dealt with the transition of the boundary layer from the laminar to the turbulent form. Three years before this, in 1934, Sir Melvill Jones had delivered the Wilbur Wright Memorial Lecture of the Royal Aeronautical Society on the subject of "Stalling."

The Musick Memorial Trophy was established in 1938 by the citizens of Auckland, N.Z., in memory of Capt. Edwin C. Musick and six companions in Pan American Airways' "Samoan Clipper" who were lost in the South Pacific on the first commercial flight from the United States to New Zealand on January 12, 1938. The trophy is awarded "to the group, body, or individual that has recently made the contribution, development, or improvement which by its practical application has become most effective in furthering the safety of aircraft with special reference to transoceanic aviation, or directly so by increasing the efficiency of aircraft."

Sir B. Melvill Jones

The Royal New Zealand Aero Club, which has its headquarters in Wellington, N.Z., is the trustee of the Musick Memorial Trophy. Britain's Royal Aeronautical Society and America's Institute of the Aeronautical Sciences both serve as nominating bodies for possible recipients of the trophy. The executives of the Royal New Zealand Aero Club act upon the nominations and select the recipient of the Musick Memorial Trophy.

Second Annual Northeastern IAS Student Branch Convention

On April 9 and 10, the Second Annual Northeastern IAS Student Branch Convention was held at the Massachusetts Institute of Technology, with the local Student Branch acting as host. The theme was "The First 50 Years of Powered Flight." The following schools were represented: the U.S. Naval Academy, Princeton University, Boston University, New York University, Polytechnic Institute of Brooklyn, Rensselaer Polytechnic Institute, Syracuse University, The Johns Hopkins University, and M.I.T.

After registration at 9:00 a.m. on Friday, April 9, the delegates were greeted by Dr. J. C. Hunsaker, Professor of Aeronautical Engineering (Emeritus) and former Head of the Aeronautical Department at M.I.T. and present Chairman of the NACA. Dr. Hunsaker turned the meeting over to Program Chairman William Moody who enumerated the student papers to be presented. These papers and the students delivering them were: "Vibration Analysis of Helicopter Blades" by Shell Salzman, M.I.T.; "Cross Coupling Between Lateral and Longitudinal Bending and Torsion Modes" by Jerry Reed, M.I.T.; "Low-Speed Ram-Jet Design" by Angelo George Cicolani, Midshipman, U.S.N.A.; "Low-Speed Wind Tunnel Using Smoke" by Bob Skodis, Princeton; and "Low R-N Wing Design" by Roger Barren, Princeton. The Judging Committee was composed of one representative from each school.

Following luncheon, the visitors were taken on guided tours of M.I.T., including the Technology Aero Department, the wind tunnels, the Gas Turbine Lab, the shock tube, and the Hydrodynamics Lab. Demonstrations were made in many of the areas visited.

Friday night, Reeves Morrison, of United Aircraft Corporation's Pratt & Whitney Aircraft Division, spoke on the progress of turbine and atomic power plants for aircraft. Following a discussion period, movies of the 1953 Farnborough Air Show and of M.I.T.'s Aero Department were shown.

On Saturday morning, April 10, the delegates boarded busses and journeyed to nearby Hascomb AFB, where the latest equipment worn by the modern jet fighter pilot was demonstrated.

That evening, at a banquet, the awards for the best student papers were presented to Shell Salzman, of M.I.T., for the best graduate paper and to Midshipman Angelo Cicolani for the best undergraduate paper. Speeches were then given by Charles Kirchner, Assistant to the President of The Kaman Aircraft Corporation, on the role of the helicopter and convertiplane during the next 50 years, and by Joseph Sutter, Boeing Airplane Company, on the future of commercial jet aviation as exemplified by the Boeing 707. Mr. Sutter was greeted with such a barrage of questions after his talk that Chairman Moody was finally forced to conclude the discussion.

The last two orders of business were congratulations to Chairman Bill Moody for the fine job he had done and a request by him for volunteers for host for next year's convention.

WILLIAM J. PRAGLUSKI
Secretary-Treasurer
IAS Student Branch, M.I.T.

IAS Welcomes New Corporate Member

Stanley Aviation Corporation, now located at Buffalo Municipal Airport, Buffalo, N.Y., has joined the Institute of the Aeronautical Sciences as a Corporate Member.

Since the company was founded in July of 1948 by R. M. (Bob) Stanley, Stanley Aviation has grown steadily and today employs approximately 400 people and occupies over 71,000 sq.ft. of plant space at Buffalo Municipal Airport. By midsummer of this year, the company expects to move into a new 65,000-sq.ft. facility adjacent to Stapleton Airport in Denver, Colo.

Included among the Stanley Aviation projects and products are ejection seats, automatic lap belts, training devices, and equipment and study projects in the guided missile field. Entry into the ejection-seat field occurred when the company won a USAF design competition for a downward ejection seat. Before these had been delivered to the Air Force, the company received a contract from Boeing Airplane Company for downward ejection bombardiers' and navigators' seats for the XB-52 aircraft. Today, the company is designing and fabricating ejection and nonejection seats under 34 prime contracts and purchase orders calling for navigator, bombardier, and tail-gunner seats.

IAFS Technical Director Named IAS Members Assisting

Dr. Hans H. Bleich, Professor of Civil Engineering at Columbia University, was recently appointed Technical Director of the Institute of Air Flight Structures. The Institute of Air Flight Structures was established the first of this year at Columbia University's Engineering Center on a grant from the Daniel and Florence Guggenheim Foundation.

Assisting Dr. Bleich in the discharge of his duties are three IAS members, all of whom are Professors in Columbia's Department of Civil Engineering. These members are: Alfred M. Freudenthal, MIAS; Bruno A. Boley, MIAS; and Lee Arnold, TMIAS.

Grover Loening, IAS Fellow and Benefactor, is Chairman of the Advisory Council of the Institute of Air Flight Structures. Further information relative to the Advisory Council membership and the formation of the Institute of Air Flight Structures will be found on page 37 of the June, 1954, issue and on page 63 of the January, 1954, issue, respectively, of the AERONAUTICAL ENGINEERING REVIEW.

S.L.A. Translations' List

The Special Libraries Association has announced that a list of translations in the S.L.A. Translations Pool is now available for distribution. Requests for copies, accompanied by $0.30 to cover the cost of postage, should be addressed to: S.L.A. Translations Pool, John Crerar Library, 86 E. Randolph St., Chicago 1, Ill.

This 73-page list comprises 1,100 translations that were in the Pool as of October 1, 1953. An addendum to cover several hundred translations contributed in the interim will be issued shortly.

Necrology

Herbert Olden

Herbert Olden, MIAS, who was recently promoted from Associate Editor to Managing Editor of *Aviation Age*, died on May 3 of a coronary occlusion. Mr. Olden was 35 years old.

A native of New York City, Mr. Olden attended the local James Monroe High School and subsequently matriculated at the College of Engineering, New York University. He received his B.A.E. degree in 1941. Immediately after his graduation, he entered the U.S. Army Air Force and served as an Engineering Officer until his separation from the service as a Major in December of 1945.

In January of 1947, he joined Pan American World Airways, Inc., as an Aeronautical Engineer. In June of that year, he re-entered the Air Force and was assigned as a Student Officer for a year of study in meteorology to the University of Chicago. He served for 2 years following the completion of this meteorological course as a USAF Weather Officer. Early in 1952, he became associated with the Eclipse-Pioneer Division of Bendix Aviation Corporation as a Technical Writer. He went with *Aviation Age* as Assistant Editor in December of 1952.

Mr. Olden is survived by his widow, Mrs. Norma Olden, and their 8-year-old son, Daniel.

News of Members

▸ **Rear Admiral Calvin M. Bolster, USN (Ret.)** (F), Coordinator of Development, The General Tire & Rubber Company, has been named to the Technical Advisory Board of General Tire & Rubber's subsidiary, Aerojet-General Corporation.

▸ **Joseph M. Chase** (AM), Manager, Division of Aircraft Maintenance and Equipment, Flight Safety Foundation, is currently General Chairman of the National Safety Council's Air Transport Section.

▸ **Dr. Karl T. Compton** (F), Chairman of the Corporation, Massachusetts Institute of Technology, was awarded Dickinson College's annual Priestley Memorial Award. The award, presented to Dr. Compton on April 23, was given to him for "distinguished contribution to the welfare of mankind through physics."

▸ **Daniel F. DeSanto** (TM), Graduate Student, College of Engineering, New York University, has been awarded a National Science Foundation fellowship for research in aeronautical engineering. The award carries with it a stipend of $1,800 plus full tuition. Mr. DeSanto will work toward a doctor's degree in the problem of flutter of airfoils in multistage cascade.

▸ **William P. Lear** (AF), Chairman of the Board and Director of Research and Development, Lear Incorporated, has been awarded one of the 1954 Horatio Alger Awards. The presentation was made on May 6 in New York.

▸ **Ralph H. McClarren** (AF), Consulting Engineer, has moved his consulting offices from Philadelphia to 600 York Rd., Jenkintown, Pa. The telephone numbers at this new address are Turner 3454 and Turner 3455.

▸ **Dr. Ing. S. Neumark** (AF) has been promoted to Senior Principal Scientific Officer, Royal Aircraft Establishment, Ministry of Supply, England. He was also recently elected to the grade of Fellow in the Royal Aeronautical Societv.

▸ **George H. Scragg** (M), Owner-Consultant, George H. Scragg Organization, announces the relocation of his sales promotion firm to 920 E. 79th St., Cleveland 3, Ohio. The telephone number there is EXpress 1-2707. The address for mail and parcel post remains the same—P.O. Box 2170, Sta. H, Cleveland.

▸ **Dr. Milton D. Van Dyke** (TM), Ames Aeronautical Laboratory, NACA, has been awarded a U.S.

(*Continued on page 60*)

Dr. von Kármán presides at the opening of AGARD's Fourth International Congress in the Kurhaus, Scheveningen, Holland, May 5, 1954. Seated with him is Dr. Frank L. Wattendorf, AGARD Secretariat Director. Prince Bernhard of the Netherlands (*seated center of front row*) made the welcoming address.

Editorial

AGARD

An important NATO organization comes of age.

Outside a relatively small circle of people working in international and military fields, the somewhat cryptic combination of letters which appears at left has heretofore had little significance. It stands, of course, for "Advisory Group for Aeronautical Research and Development," an organization fathered by the Chairman of the U.S. Air Force Scientific Advisory Board and brought into being by the Standing Group of the Military Committee of the North Atlantic Treaty Organization. All of which sounds a bit complicated, but dug out from behind these resounding titles, AGARD is really the product of the genius and foresight of one man, Theodore von Kármán. Dr. von Kármán early recognized that great talent for aeronautical development existed in the NATO countries but that some coordinating device was needed to prevent wastage and duplication of our scientific effort. A meeting was called in Washington in February, 1951, at which representatives of Canada, Denmark, France, Italy, the Netherlands, the United Kingdom, and the United States discussed the problem. By common consent,

AGARD was set up on a provisional basis for a 2-year period, during which time it was to receive logistical support from the U.S. Air Forces.

The Advisory Group established the following objectives:

(1) To review continuously the application of advances in aeronautical science to common defense problems.

(2) To make recommendations for the solution of problems referred to it by agencies within NATO, including evaluation of research and development projects submitted by individual nations.

(3) To make recommendations leading to improved cooperation among member nations in the field of aeronautical research and development.

(4) To explore methods for facilitating exchange of information pertaining to aeronautical research and development.

During its short existence, under the direction of Dr. von Kármán and with the aid of a small technical staff in Paris, AGARD has succeeded in carrying out its announced objectives so well that there was no question of its continuation after the 2-year trial period. The participating nations have agreed to relieve the USAF of the logistical responsibility and have budgeted funds to carry on the work. This is good. It is a long step in the direction of international cooperation for mutual defense. AGARD provides an example that might well be followed in other areas of common interest. Dr. von Kármán's faith in the future has been well justified.

We of the Institute are proud to have participated to a small degree in the work of AGARD. One of its important areas of interest is in documentation, in facilitating the exchange of technical information by standardization of methods, report forms, and terminology. In the Spring of 1953, IAS Western Manager E. W. Robischon was made available (on loan) to the AGARD Paris office to help lay the groundwork for the Documentation Panel. Also, during the past two General Assemblies (London, August, 1953, and Holland, May, 1954), the Institute was invited to participate on an official basis. IAS Secretary Robert R. Dexter sat with the Documentation Panel on both occasions and is doing everything possible to make appropriate IAS facilities available to AGARD. Our libraries and our indexing and reviewing services are now being used. Many IAS members are also participating in the work of the technical panels. In these, and in other ways, your Institute is taking part in the advancement of the aeronautical sciences on a world-wide basis. S.P.J.

A summary report of the recent AGARD meeting in Holland will appear soon in a forthcoming issue of the Review.—Ed.

Effect of Aircraft Jet-Engine Exhaust Impinging on Airfield Surfaces

N. L. FOX* and S. J. HARVEY†

Santa Monica Division, Douglas Aircraft Company, Inc.

ABSTRACT

Available information regarding the effect of aircraft jet-engine wakes on airfield surfacing materials is summarized and discussed. These data show that the temperature of the exhaust gases incident on the pavement surface may be predicted from the exhaust gas temperature, jet nozzle angle, and height-to-diameter ratio. Temperatures in the pavement may then be predicted from the thermal properties of the material and the time of exposure. Moving nonafterburning aircraft do no damage because of the limited time of exposure; stationary nonafterburning and slowly moving afterburning aircraft may produce pavement surface temperatures sufficient to cause appreciable damage. This damage starts at about 300° F. for asphalt and 800°F. for concrete pavements in current use. The problem of loose material being blown away is more severe than, but similar to, the situation with propeller slipstreams. Danger of fires from jet-engine wakes seems remote.

NOMENCLATURE

a	=	thermal diffusivity of paving material, sq.ft. per hour
B_i	=	generalized Biot Number, hZ/k
C	=	constants, defined where used
D	=	diameter of jet exhaust nozzle, in.
F_o	=	boundary Fourier Number, $h^2a\theta/k^2$
H	=	height of jet exhaust nozzle centerline from ground, ft.
h	=	forced convection thermal coefficient, B.t.u. per °F. hour sq.ft.
k	=	thermal conductivity coefficient, B.t.u. per °F. hour ft.
P_r	=	Prandtl Number
R_e	=	Reynolds Number
T	=	temperature at any particular point in space (stagnation if in a moving gas), °R.
T_a	=	ambient air temperature, °R.
T_j	=	jet exhaust stagnation temperature, °R.
T_s	=	jet wake gas stagnation temperature incident on the ground surface
T_z	=	temperature at depth Z in pavement, °R.
Y	=	radial distance from jet centerline extension, ft.
X	=	distance from jet nozzle exit, parallel to jet nozzle centerline, ft.
X'	=	distance from jet nozzle exit, parallel to ground surface, ft.
Z	=	distance below pavement surface, ft.
α	=	angle between jet centerline and ground surface (positive when afterend of engine is tilted downward), deg.
θ	=	time, hour
$(/)_{max.}$	=	maximum value in a particular plane

INTRODUCTION

JET AIRCRAFT are already in extensive use by the Armed Forces and are being considered by commercial operators. Their use is extending existing airport problems and introducing new ones, such as:

(1) The effect of the hot high-velocity engine exhaust on airport surfacing materials.

(2) Fuel spillage.

(3) Noise.

(4) Increasing wheel loading and tire pressures.

Only the first of these problems will be dealt with here.

With the increasing use of jet aircraft, this problem may become increasingly important to airport operators, naval aircraft carriers, and air-frame manufacturers. Relatively little engineering data have been published in this country on the effect of aircraft jet-engine exhaust on airport surfacing materials. Most of the past experience has been with military combat aircraft but is indicative of the coming problem with commercial and military transport jet aircraft.

This problem may be divided into two portions:

(A) The temperature and velocity of the jet wake immediately above (incident upon) the ground surface, as affected by aircraft geometry and engine operating condition.

(B) The reaction of various airport surfacing materials to surface temperature and velocity.

Because the temperature and velocity distribution patterns in a jet wake are similar, only one of these need be analyzed. The temperature variable has been chosen because damage to hard surface paving materials is the more crucial problem. On the other hand, loose surface material will be affected more by the velocity. This portion of the problem being similar to, although more severe than, the situation with propeller-driven aircraft will receive only minor discussion.

GENERAL ASSUMPTIONS

Throughout this report, several general assumptions are made:

(1) *The aircraft or model jet is stationary with respect to both the ground surface and the free air stream.* As shown later, the time of exposure of a particular pavement area to the jet wake of a moving aircraft is insufficient to cause appreciable temperature rise. Consequently, hard surface pavements are not damaged. Conversely, loose surface materials, affected by the jet wake velocity, may be damaged by moving aircraft.

(2) *All jet-engine exit nozzles and test model nozzles are circular.* This is the usual case. For the two exceptions, the "clam-shell" variable-area nozzle and the

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nozzle in which a center "bullet" protrudes into the exit plane, an effective diameter based on the minimum area arbitrarily has been used. The effect of devices used for minor adjustments to the exit area of fixed-area nozzles has been neglected.

(3) *Ambient air temperature, T_a, is 59°F. (15°C.) unless otherwise stated.* It may be that the gas temperature incident on the ground is insensitive to ambient air temperature. For one engine investigated, the correlation presented later yielded approximately the same temperatures incident on the ground for —40° F. to +100°F. air temperatures, because of the combined effects of ambient temperature, T_a, and the resulting changes in the jet temperature, T_j.

(4) *The initial (undisturbed) ground temperature is equal to the ambient air temperature.* Where data are available to show that this is not the case, the air temperature should be used in finding the temperature incident on the ground, and the initial ground temperature in finding the ground temperature rise.

(5) *The ground or pavement surface is a uniform gecmetrically flat plane.* The effect of surface roughness, depressions due to prior damage, and pavement discontinuities has been neglected. Jet blast deflectors are not considered here.

Correlation of Aircraft Geometries

It is assumed that pavement damage occurs initially, and is most serious, at the point on the ground surface where the temperature of the incident jet wake is a maximum.

Several theoretical analyses have been made for the temperature distribution in an undisturbed jet wake—i.e., a jet expanding into quiescent air with no solid boundaries within the region of influence. These analyses do not appear capable of treating the effect of solid boundaries, such as the ground plane, nor are they completely satisfactory in other respects.

Consequently, these analyses have been abandoned, and less complicated empirical correlations have been employed. A number of articles give experimental data describing the temperature distribution in an undisturbed jet wake expanding into quiescent air.[1] A sketch of such data is shown in Diagram 1 in the form of a map of constant temperature contours.

Several of these articles give correlations that, while not completely adequate, lead to the following assumptions:

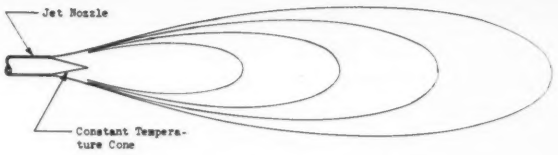
(1) The temperature distribution in jet wakes is axially symmetric about the jet nozzle centerline extended, as long as natural convection is not important. Natural convection becomes important only far beyond the present region of interest for jet aircraft or any reasonable model simulation thereof.

(2) Geometric similarity of dimensions applies regardless of scale. Linear dimensions are usually presented in terms of jet nozzle exit diameters.

(3) Temperature distribution patterns in jet wakes are similar, independent of the jet nozzle gas temperature. Temperature data show reasonable agreement when presented in the form of a temperature parameter, which is defined as the temperature rise over ambient air temperature of the gas at a point in the jet wake, divided by the jet nozzle gas temperature rise over ambient. In terms of the nomenclature adopted here, this temperature factor is:

$$(T - T_a)/(T_j - T_a)$$

This form of a temperature factor later will be found convenient, as it is similar to temperature factors that result from several of the classical heat-transfer equation solutions.



Constant temperature profiles in an undisturbed jet wake.

Diagram 1.

(4) The aforementioned temperature factor is inversely proportional to distance downstream in the region downstream from the initial constant temperature cone (see Diagram 1). This cone is on the order of 5 jet diameters long with the jet nozzle exit forming its base. The expression

$$(X/D)[(T - T_a)/(T_j - T_a)]_{\text{centerline}} = \text{constant}$$

is a reasonable representation of the experimental data, although there is a small variation in the constant as other conditions change.

(5) Downstream from the initial constant temperature cone, cones are formed by the locus of points where the temperature factor is a constant fraction of the value on the jet centerline at the same distance downstream. The apex of this cone is approximately at the center of the jet nozzle exit, and its apex angle is a function of the temperature factor fraction chosen. (See Diagram 2.) This is to say:

$$\frac{[(T - T_a)/(T_j - T_a)]_{\text{at a}}}{[(T - T_a)/(T_j - T_a)]_{\text{at b}}} = \text{a function of } \left(\frac{Y}{X}\right)$$

independent of the individual value of X.

(6) Assumption (5) leads to the fact that the shapes of temperature profile vs. radial distance (for a constant distance downstream) are similar—i.e., independent of

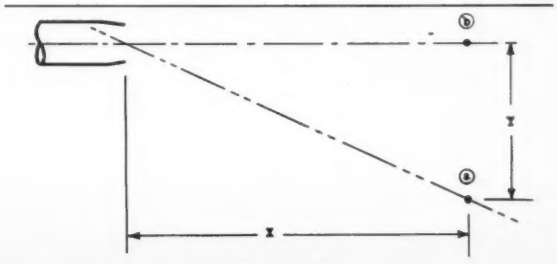


Diagram 2.

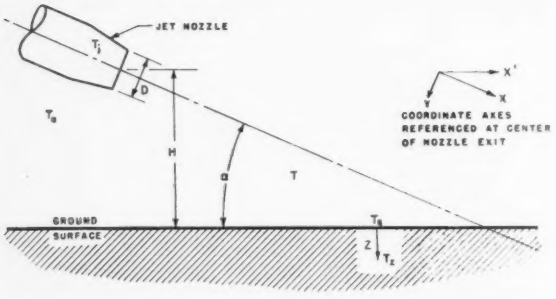


FIG. 1

the particular distance downstream. This fact has been used to extend experimental data into regions where measurements are difficult. Several mathematical functions have been used to represent this shape; it appears that the best of these is

$$T - T_a = C_1[1 + \cos(C_2 Y)] \qquad \begin{matrix} C_2 Y < \pi \\ X/D > 5.0 \end{matrix}$$

where C_1 and C_2 are constants. Other functions often used are the probability function and the three-halves power.

(7) Other characteristics such as velocity, pressure, density, turbulence level, and chemical composition of the gas leaving the jet nozzle are apparently of secondary importance for the cases of interest here and will be neglected.

As mentioned earlier, most of these assumptions are only in fair agreement with experimental data. The relationships described by these assumptions may be combined to yield the following empirical expression:

$$\frac{T - T_a}{T_j - T_a} = C_3 \frac{D}{X}\left[1 + \cos\left(C_4 \frac{Y}{X}\right)\right]$$

$$\begin{matrix} C_4 (Y/X) < \pi \\ X/D > 5.0 \end{matrix} \qquad (1)$$

where the constants C_3 and C_4 are to be evaluated from experimental data. Trial has shown that, while this expression is only approximate, even for the temperature distribution in a single jet wake, it appears to be as good as any similar expression available. Average values for the constants appear to be:

$$C_3 = 2.5$$
$$C_4 = 12.8 \text{ (radians)}$$

Because of lack of sufficient information, it will be assumed for this analysis that the effect of the ground plane on the temperature distribution in the jet wake is negligible (see page 30, paragraph A). The equation of the ground plane then may be substituted into Eq. (1) to determine the temperature distribution incident on the ground surface. Experimental values for both these temperature distributions are given in reference 2.

This analysis may be simplified by limiting it to the plane that is perpendicular to the ground surface and which contains the jet centerline. The assumptions leading to Eq. (1) indicate that this is a plane of symmetry and that this plane will contain the maximum temperature incident on the ground. Fig. 1 shows the location of the pertinent variables in this plane.

The equation of the ground plane (line) is now

$$Y = (H/\cos\alpha) - X \tan\alpha \qquad (2)$$

By substituting Eq. (2) into Eq. (1), the variable Y may be eliminated. The resulting equation will give calculated values for the gas temperature incident on the ground surface. This is shown in Fig. 2 with a corresponding set of experimental data. Fig. 2 is typical of several other comparisons of calculated and experimental data; it shows the experimental curve to be displaced, both in distance downstream and in temperature magnitude, from the calculated values. The shapes of the two curves, however, are similar, and the calculated curve is useful in interpolating between experimental points, such as for obtaining the maximum temperature value. This discrepancy may be due to the particular values of the constants substituted into Eq. (1) and constraint by the ground surface of the cool ambient air for mixing. By obtaining values of the constants from experimental curves such as Fig. 2, a more satisfactory prediction may result, although a third constant (displacement of the jet wake from centerline) may be necessary in this case

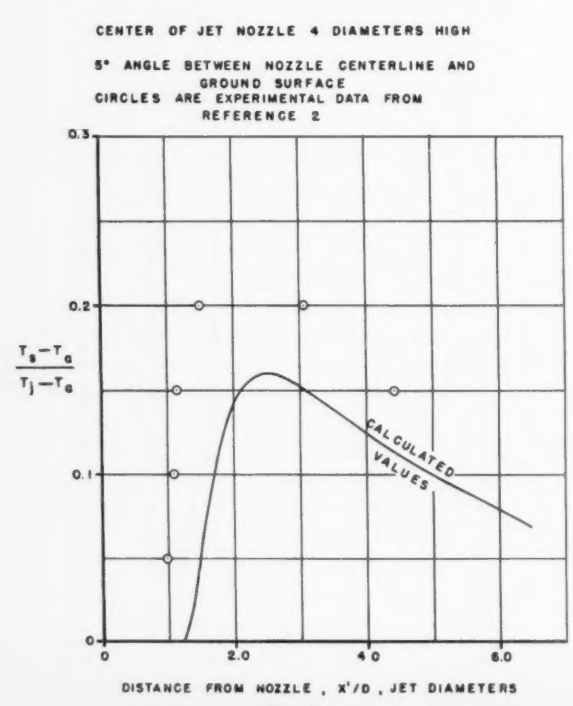


FIG. 2.

The maximum value of temperature on plots such as Fig. 2 is the main point of interest. It should be possible to differentiate the expression resulting from Eqs. (1) and (2) to obtain the maximum value of the temperature. This, however, results in a cumbersome expression that has no apparent explicit solution. It was found by numerical evaluation that two of the dimensionless groups may be combined to yield the following approximate functional relationship:

$$[(T_s - T_a)/(T_j - T_a)]_{max.} (H/D) = f(\alpha) \qquad (3)$$

This shows that for a given jet engine, the maximum gas temperature incident on the ground surface is inversely proportional to the height of the jet exit above the ground. Fig. 3 gives a comparison of calculated and experimental values for this functional relationship. These curves show the same temperature discrepancy as Fig. 2. Any discrepancy in the downstream distance at which the maximum temperature occurs does not directly affect Fig. 3.

Several comments are in order regarding the experimental data shown in Fig. 3. Throughout this report, the ground plane temperature, T_s, is defined as the jet wake gas stagnation temperature incident on the ground surface. As shown later, temperatures on the surface, or at a finite depth below the surface, exhibit in appreciable time lag from the incident gas temperature. Some of these data have been corrected analytically, by the methods given later in this report (Eq. 4), to make them comparable. At least part of the scatter of the experimental data in Fig. 3 may be due to the questionable accuracy of these corrections, due to lack of knowledge of the exact thermal properties of the pavement materials used and the surface heat-transfer coefficient. Specifically:

(A) *Reference 2* (⊙)—Data represent thermocouples at the surface of an "insulating" plate. No corrections used.

(B) *Reference 3* (▽ *and* △)—Data represent the hottest of four thermocouples at the surface of a concrete slab, after consecutive periods of 3 min. at 60 per cent power (▽) and 3 min. at 100 per cent power (△). Corrected for surface lag only, correction factors being on the order of 1.4. Observed temperatures may be low due to a thermocouple not being located at the highest temperature point. (See Fig. 2.)

(C) *Reference 4* (+)—Situation not described. No corrections used.

(D) *Reference 5* (×)—Data represent thermocouples at $^1/_2$-in. depth in concrete after a 13-min. run period. Corrected for surface plus depth lags, correction factors being on the order of 2.6.

Decreased accuracy is expected as the correction factor increases.

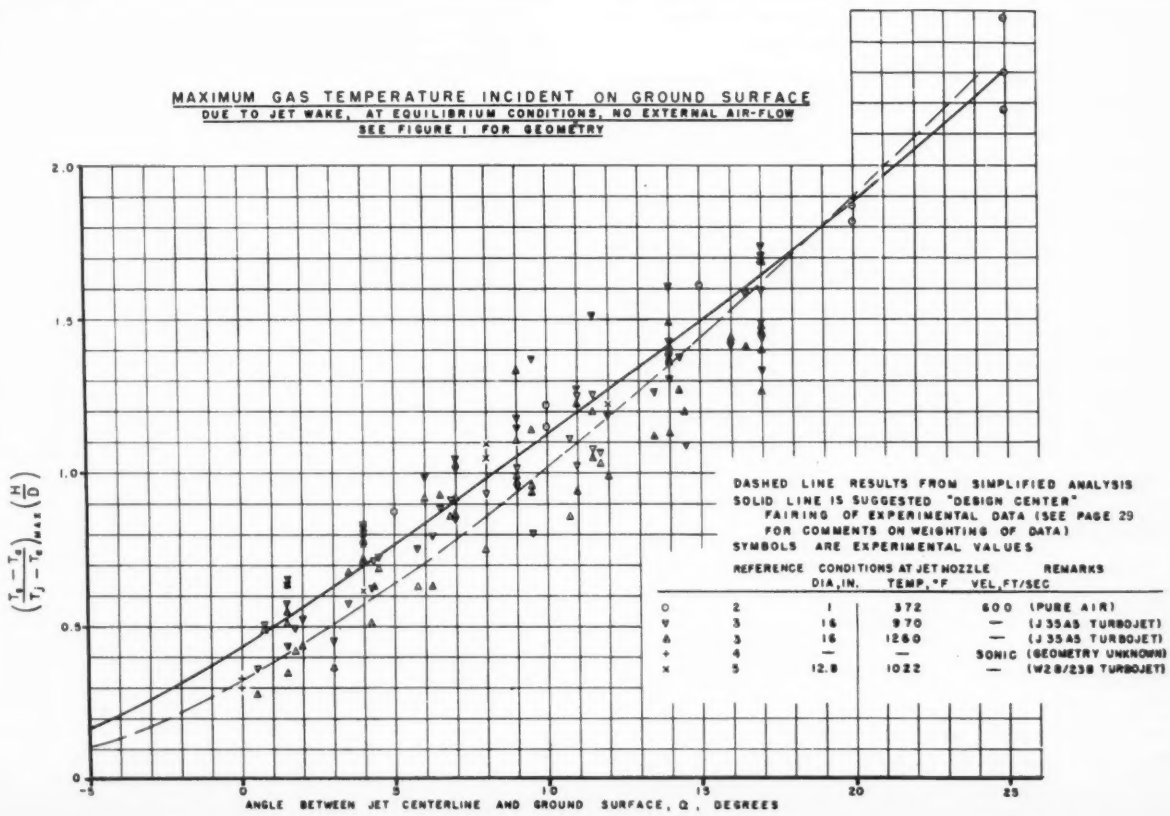

MAXIMUM GAS TEMPERATURE INCIDENT ON GROUND SURFACE
DUE TO JET WAKE, AT EQUILIBRIUM CONDITIONS, NO EXTERNAL AIR-FLOW
SEE FIGURE 1 FOR GEOMETRY
$\left(\frac{T_s - T_a}{T_j - T_a}\right)_{max} \left(\frac{H}{D}\right)$
2.0
1.5
1.0
0.5
0
-5
0
5
10
15
20
25
ANGLE BETWEEN JET CENTERLINE AND GROUND SURFACE, α, DEGREES
DASHED LINE RESULTS FROM SIMPLIFIED ANALYSIS
SOLID LINE IS SUGGESTED "DESIGN CENTER" FAIRING OF EXPERIMENTAL DATA (SEE PAGE 29 FOR COMMENTS ON WEIGHTING OF DATA)
SYMBOLS ARE EXPERIMENTAL VALUES
REFERENCE | CONDITIONS AT JET NOZZLE: DIA, IN. | TEMP, °F | VEL, FT/SEC | REMARKS
○ 2 1 372 600 (PURE AIR)
▽ 3 16 970 — (J35A5 TURBOJET)
△ 3 16 1260 — (J35A5 TURBOJET)
+ 4 — — SONIC (GEOMETRY UNKNOWN)
× 5 12.8 1022 — (W28/2B TURBOJET)

FIG. 3.

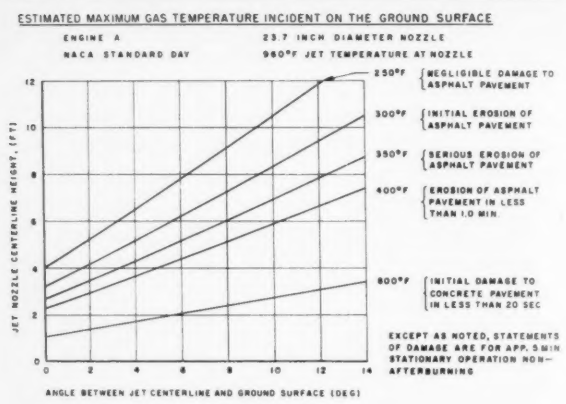

ESTIMATED MAXIMUM GAS TEMPERATURE INCIDENT ON THE GROUND SURFACE
ENGINE A
NACA STANDARD DAY
23.7 INCH DIAMETER NOZZLE
960°F JET TEMPERATURE AT NOZZLE
250°F NEGLIGIBLE DAMAGE TO ASPHALT PAVEMENT
300°F INITIAL EROSION OF ASPHALT PAVEMENT
350°F SERIOUS EROSION OF ASPHALT PAVEMENT
400°F EROSION OF ASPHALT PAVEMENT IN LESS THAN 1.0 MIN.
800°F INITIAL DAMAGE TO CONCRETE PAVEMENT IN LESS THAN 20 SEC
EXCEPT AS NOTED, STATEMENTS OF DAMAGE ARE FOR APP. 5 MIN STATIONARY OPERATION NON-AFTERBURNING
JET NOZZLE CENTERLINE HEIGHT, (FT)
ANGLE BETWEEN JET CENTERLINE AND GROUND SURFACE (DEG)

FIG. 4.

Several interesting facts may be deduced from the experimental data shown in Fig. 3.

(A) For low values of α, the angle between the jet centerline and ground plane, the mean of the experimental data shows higher temperatures incident on the ground surface than predicted by the undisturbed jet wake temperature distributions. This is due to the fact that the ground surface restrains the cool air available for mixing with the hot jet in this region. Because such restraint may result from any surface, it is also expected that adjacent aircraft surfaces such as wings or flaps may have a small effect on maximum ground temperatures. It should be noted that all the data shown were obtained with no solid bodies in or adjacent to the jet wake except the flat ground plane.

(B) While not shown, the values of (H/D) for the experimental points of Fig. 3 show random variation and not a trend. Apparently combining the variable groups $[(T_s - T_a)/(T_j - T_a)]_{max.}$ and (H/D) does not produce the scatter shown.

(C) Within the scatter of the data, values for the model jet (a 1-in. diameter pure air jet of relatively low temperature differential) and for full-scale jet-engine exhaust show reasonable agreement. This indicates that reasonable confidence may be placed in experimental work performed at model scale (dimensions and temperature factor) and extrapolated to full scale by use of these parameters. There is some evidence that the jet nozzle pressure or density ratio will have a small effect on spreading of an undisturbed jet. The scatter of the data presented in Fig. 3, however, prevents any conclusions on the matter.

The nondimensional correlation of Fig. 3 may be used to estimate the maximum temperature incident on the ground surface for a given airplane. An example of this is given in Fig. 4, showing the estimated maximum temperature of the exhaust gases impinging on the ground surface, as a function of the height and angle of the exhaust, for the commercial version of a large turbojet engine soon to be available. The curves of Fig. 4 have been computed from the "Design Center" fairing of the experimental data in Fig. 3 and represent a "best guess." Using the upper limit of the bulk of the experimental data yields temperatures in Fig. 4 approximately 50°F. higher. As mentioned previously, the only apparent reasons for the data in Fig. 3 to be higher than the true maximum temperature are experimental accuracy and overcorrection for surface or subsurface time lag.

The table of operating experience contains temperature estimates and comparisons of these estimates with test data for aircraft for which sufficient unclassified information is available. Again, the experimental temperature data are of questionable validity because of lack of a sufficient statement as to the location of the temperature sensing device—i.e., gas temperature incident on the surface, surface temperature, or subsurface temperature. The estimated temperatures are the highest of these three.

Limiting engine operation to partial throttle reduces the jet temperature rise less than might be expected. For example, it has been found that one large bomber engine idles at 43 per cent, and a smaller fighter type at 73 per cent of the maximum jet temperature rise, $T_j - T_a$.

Effect of Temperature on Airfield Surfacing Materials

Effect of Time

An analysis has been made to determine the effect of exposure time on ground temperatures. It is unlikely,

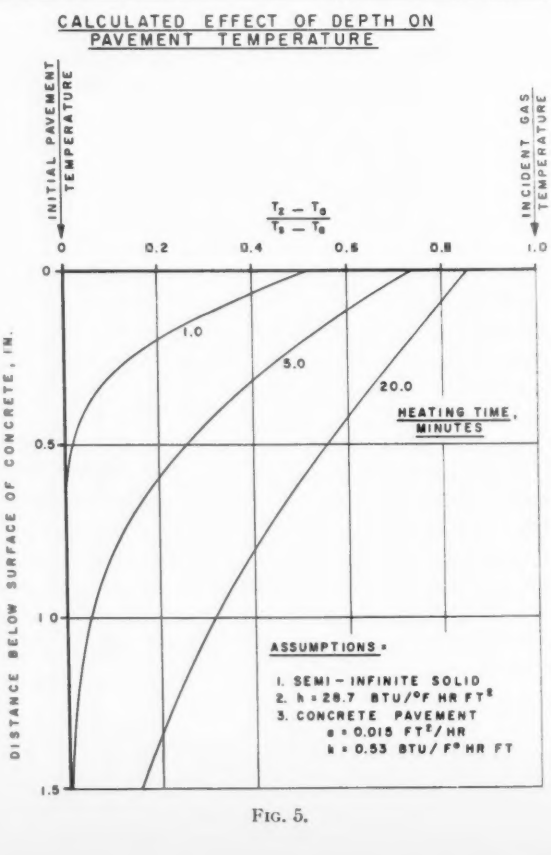


FIG. 5.

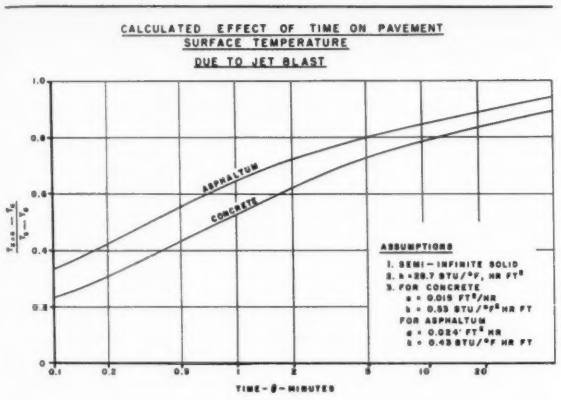

CALCULATED EFFECT OF TIME ON PAVEMENT SURFACE TEMPERATURE DUE TO JET BLAST
ASPHALTUM
CONCRETE
ASSUMPTIONS
1. SEMI-INFINITE SOLID
2. h = 28.7 BTU/°F, HR FT²
3. FOR CONCRETE
a = 0.015 FT²/HR
k = 0.55 BTU/°F HR FT
FOR ASPHALTUM
a = 0.024 FT² HR
k = 0.43 BTU/°F HR FT
TIME - θ - MINUTES

FIG. 6.

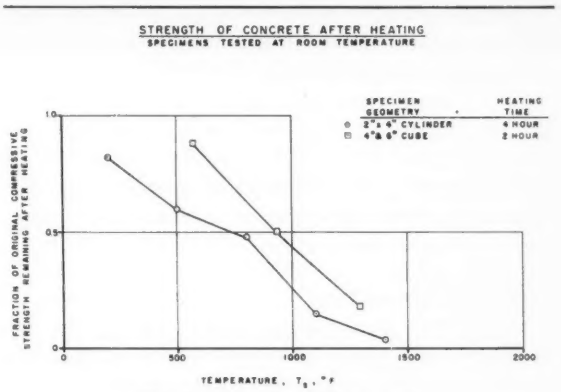


FIG. 7. Data from reference 11.

of course, that the engines of operational jet aircraft will be run for long periods of time on the ground because of their high rate of fuel consumption.

The subsurface temperature distribution produced by a hot jet impinging on the ground may be studied by considering a semi-infinite solid suddenly exposed to a fluid at a higher temperature. Assuming that the pavement composition and initial temperature are independent of the depth, Z, and that the dimensions and thermal properties are independent of the local temperature, T_z, reference 6 gives, as an analytical solution

$$\frac{T_z - T_a}{T_s - T_a} = 1 - erf\left(\frac{B_i}{\sqrt{4F_o}}\right) - e^{(B_i + F_o)} \times \left[1 - erf\left(\frac{B_i + 2F_o}{\sqrt{4F_o}}\right)\right] \quad (4)$$

where

B_i = Biot Number = hZ/k

F_o = Fourier Number = $h^2a\theta/k^2$

$erf\ u$ = error function of $u = \frac{2}{\sqrt{\pi}} \int_0^u e^{-v^2}\, dv$

and the remaining symbols are defined in the nomenclature. This shows that the temperature rise of any point in the pavement, divided by the temperature rise of the gas incident upon the surface of the pavement, is a function of the time, θ; of the depth, Z, of the point in question; the thermal properties, k and a, of the pavement; and the surface heat-transfer coefficient, h. Reference 6 also gives numerical solutions of Eq. (4) in graphical form.

Eq. (4), based on theory, assumes no heat transfer parallel to the surface and has been shown to be an excellent representation of experimental data when the constants are reasonably accurately evaluated. The constants used here (given in Figs. 5 and 6) were selected from published literature with the exception of h, which was calculated from a modified form of the usual equation:

$$hx/k = C_b(R_e)^{C_6}(P_r)^{C_7} \quad (5)$$

for a 400-ft. per sec. velocity, 20-ft. effective length, and air at 340°F.

No attempt has been made to check the curves resulting from these assumed constants (Figs. 5 and 6) against experimental data for this situation. This should be done in a complete evaluation of experimental apparatus and data.

Several numerical solutions for Eq. (4) are given in Figs. 5 and 6. Fig. 5, the temperature distribution in concrete as a function of the depth, Z, with time, θ, as a parameter, shows that the temperature penetration into the pavement is relatively shallow. Experimental data lead to the same conclusion. This indicates that damage will be confined to the exposed surface of the pavement, with relatively little structural weakening of the material except that visible on the surface. Test data on the compressive strength of concrete after heating is given in Fig. 7 as an indication of the structural weakening expected (see description of concrete paving).

Fig. 6, the surface temperature ($Z = 0$) of concrete and asphalt pavements as a function of time, θ, shows that:

(1) The surface temperature of asphalt will rise faster than that of concrete. This is due only to the change in the thermal conductivity, k, and diffusivity, a, which, depending upon the aggregate used in the paving material, may also vary.

(2) The problem may be alleviated somewhat by limiting the continuous engine running time at a fixed location to about 1 min. References 7 and 9 give average times experienced at an operational base (military jet aircraft) as:

	Single-Engined Aircraft, Min.	Four-Engined Aircraft, Min.
Starting	3.5	10.0
Pre-take-off	1.5	2.5
Maintenance	14.0	14.0

The maintenance times listed above are sufficient to cause nearly the maximum amount of surface temperature rise for a particular aircraft.

(3) Temperatures reached in paving materials when nonafterburning aircraft are moving are no problem, because of the short time of exposure of the pavement surface to the jet wake. This is amply borne out by experience.

The temperature parameter of Eq. (4) is in a form convenient to apply as a correction factor to the temperature parameter of Eq. 3:

$$\frac{T_z - T_a}{T_s - T_a} \times \frac{T_s - T_a}{T_j - T_a} = \frac{T_z - T_a}{T_j - T_a}$$

As mentioned earlier, this type of correction has been used to make the various sets of experimental data presented in Fig. 3 comparable.

Damage to Unpaved Areas

This portion of the problem is much the same as that produced by propeller-driven aircraft, accentuated by higher power levels. Damage here consists of material removal, in various forms from dust clouds to large pieces (to 100 lbs.) which may be thrown several hundred feet. Application of a thin asphalt treatment apparently is not the solution,[7] as it only increases the size of the pieces of material removed. Soil cement, a mixture of Portland cement and earth, has been partially satisfactory when not subjected to traffic. A remedy currently being utilized is some form of steel mat or mesh, *firmly* staked down. In certain cases, steel runway matting has been rolled up by the jet wake. Such steel mat reduces, but does not eliminate, material removal.

The above-mentioned material removal may be serious to established airports in two ways:

(1) By removing the grading at the edge of paved areas, structurally weakening these areas. (One case of this was noted at the Los Angeles International Airport, where dirt had been removed at the edge of a concrete holding slab to a depth of 15 in., exposing the subgrade and causing mud puddles. Wire mesh, similar to "cyclone" fencing material, had been only partially successful in halting this damage.)

(2) Danger or discomfort from the material removed. This includes window breakage from gravel, reduced visibility, personnel discomfort, etc.

Damage of this type, due primarily to the velocity rather than the temperature in the jet wake, is not expected to show the time dependency that pavement damage does. Moving aircraft will produce some damage, although the amount of material removed is to some degree a function of the time of exposure. The following is quoted from reference 12:

"In Korea, jet blast erosion of the base (subgrade) under pierced steel plank landing mats has been a principal cause of runway failure. This erosion causes ruts in the runways and creates uneven transverse grades which are particularly dangerous for jet planes carrying wing-tip tanks. Buckling of this planking and breaking of connective bayonets has reduced normal tire life 60 to 90 per cent. Many expedients have been tried, such as placing rice straw bags or mats, or opened burlap sand bags on the ground under the steel planking and treating them with asphalt cutback. None of the expedients is entirely satisfactory, and over a period of time blast erosion will ruin most pierced steel plank runways."

Danger of Fires

No cases of fires due to jet wakes, to the authors' knowledge, have been reported. Apparently combustible materials blow away before reaching their ignition temperature. Attention is called to tests made with the Canadian Avro Jetliner.[8] A flannel cloth mop, soaked in 100-octane gasoline, was held at several locations in the jet wake both with the engines running at idle and at take-off conditions. At no time did the mop show any tendency to ignite.

Description of Asphalt Paving

Technically known as Asphaltic Cement Concrete, the common asphalt paving may be classified as a semiflexible thermosetting material. It commonly consists of aggregate (gravel) with petroleum derivatives forming a water-repellent binder. The binder and aggregate are mixed hot, spread in place, and compacted (rolled). It is usually used as a surfacing material, 4 to 16 in. thick, with a specially prepared subgrade, up to 6 ft. thick, forming the load-supporting structure.

Asphalt paving is also used as an overlay, either to reinforce existing pavement or to resurface pavement damaged either locally or generally. It is extremely common to apply a 4-in. thick surface of asphalt paving to cracked or broken concrete paving.

In use, the surface of asphalt paving partially oxidizes, which further hardens the exposed layer. Repeated tire loads also tend to further compact the materials, reducing the voids (air pockets) in the paving, thereby increasing its water-repellent and load-bearing qualities. This accounts for the fact that old asphalt paving is often considered superior to newly laid material.

A common cause of pavement failure is water entering the subgrade, reducing its load-bearing quality. As asphalt paving, in the past, has had a small tendency to be porous, a thin waterproofing "seal coat" has often been applied to the surface of the pavement. This "seal coat" is also an asphalt-aggregate mixture, having a smaller size aggregate and higher percentage asphalt than the paving mixture. Modern paving practice has considerably reduced the water permeability of asphalt pavement.

Damage to Asphalt Paving

Because asphalt paving is designed as a semiflexible material, apparently the softening of the asphalt due to heating does not seriously affect the structural qualities of the pavement. Wheels, rolled through areas softened by the heat of a jet blast, produce only small surface deformation.

Evaluation of damage to asphalt paving by various sources has led to conflicting statements. Physically, this damage ranges from surface discoloration to complete removal, in the extreme case, of the pavement and a portion of the subgrade. The worst damage traceable to nonafterburning aircraft outside of maintenance or

FIG. 8. Erosion of asphalt pavement showing material removal to about 1.75 in. depth. Leveling board is a 2 by 4.

test areas is removal of material to a depth of about 2 in., as illustrated by Fig. 8.

The effect of surface discoloration, which probably starts at about 250°F., at worst, is to decrease the water-repellent quality of the pavement, permitting eventual breakdown of the subgrade. Actual material removal, which probably starts at about 300°F., appears to be to some degree a function of the time, as well as the temperature, involved. As shown in Fig. 9, most cases of material removal in the past have been elliptical areas on the order of 3 by 8 ft. and not exceeding 1 in. in depth. The asphalt binder is removed first, the aggregate being removed only when loosened. This type of damage leaves the roughened surface shown in Fig. 10 and an almost negligible depression with regard to runway level. Obviously, however, it will reduce the water-repellent and structural qualities of the pavement. As the jet aircraft traffic increases, the material removal due to repeated jet effects in the same location will probably be cumulative.

The temperatures mentioned above are the pavement surface temperatures, not the gas temperature (see Effect of Time), and must necessarily be approximate due to variation of the properties of the asphalt and aggregate used. The following unpublished estimates of temperature susceptibility are noted:

Reference	Temperature, °F.	Statement
Mr. Lackey of the Asphalt Institute	300	Limiting safe temperature
Mr. Bishop of the U.S. Naval Civil Engineering Laboratory	400	Erosion definitely occurs with optimum composition

Further data on temperatures are included in the table of operating experience.

Description of Concrete Paving

The most commonly used material falling under this description is technically known as Portland Cement Concrete and is classified as rigid pavement. It is usually laid in thickness of 4 to 22 in., depending on the design loads and bearing capacity of the soil or prepared subgrade. In the past, concrete has been laid in monolithic strips 20 to 25 ft. wide, with stress relief joints at 15- to 25-ft. intervals to accommodate expansion and contraction. These sections were sometimes joined with steel dowels to prevent vertical displacement, and the joints between sections, up to $^3/_4$ in. wide, were filled with an asphaltic sealing compound to prevent entry of foreign incompressible material and water. It is now recommended that these joints be sawed or cast slots $^1/_4$ in. or less in width and $1^1/_2$ in. deep, at about the same spacing. These slots lead to "controlled" cracking and may be filled with asphalt, asphalt-rubber mixtures, or asbestos. "Aggregate interlock" action replaces the dowels in preventing vertical displacement.

The concrete used for runways is impervious to water, but any cracks or joints may be filled with a flexible material to protect completely the subgrade from surface water. This flexible material also excludes foreign incompressible material that could cause local failure under conditions of seasonal temperature variation.

Comparative prices depend somewhat on location, but concrete paving is usually somewhat more expensive in first cost than asphalt paving that has been designed for equal load-carrying capacity.

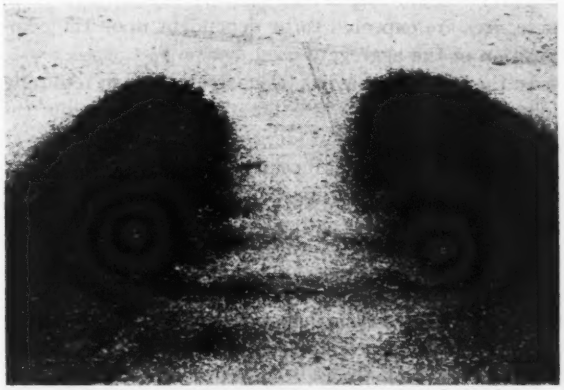


FIG. 9. Typical erosion pattern from a jet aircraft having two engines in the fuselage.

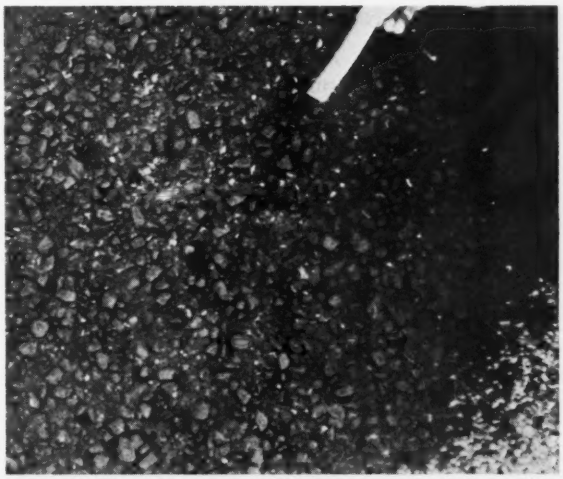


FIG. 10. Close-up of asphalt pavement surface after jet blast erosion. Note 1- by 6-in. cardboard in man's hand.

Damage to Concrete Paving

Because concrete paving supports its loads somewhat in the manner of a beam, its structural strength is important. Fig. 7 indicates the reduction in strength of small concrete specimens heated for relatively long periods of time. However, Fig. 5 indicates that high temperature penetrates only a relatively small distance into the pavement, and, therefore, this phenomenon is not expected to cause trouble.

The heat weakening of concrete mentioned above is probably due to loss of water of hydration in the cement binder. In one case, 45-min. application of a jet blast caused surface deterioration in concrete paving.

Fig. 5 indicates that a high thermal gradient may occur near the surface of concrete paving. Because concrete is a rigid material, this leads to high thermal differential expansions. The physical result is called "spalling" and consists of flaking off on the surface of the concrete, at times with explosive violence. This may occur at relatively low pavement temperatures if the thermal gradient is sufficiently great. The results of this phenomenon are expected to be cumulative when an area is subjected to repeated jet wakes.

Based on past experience, estimates of the maximum gas temperature permissible over concrete range from 800° to 900°F., but are ill-defined. Permissible temperatures are expected to be dependent upon the composition of the aggregate used.

In the past, trouble has been experienced in retaining joint sealer (asphalt) in concrete expansion joints exposed to jet blasts. Modern practice with narrower joints and improved joint sealers is expected to alleviate this problem. Studies are also in progress to determine improved joint-sealer materials.

Taxiway Markings

No paint materials have been found to date which will withstand the effect of both jet wakes and tire abrasion. Lighted runway markers, containing glass, also must be protected from direct jet wake, because of both temperature and loose flying objects in the jet wake.

Aircraft Damage

Uneven pavement surfaces resulting from material removal by and local failure due to jet wakes are obviously undesirable in several ways such as:

(1) Reduced wing-tip-ground clearance in the case of wing spans long compared to the distance between landing gear.

(2) Increased landing-gear strut normal loading.

(3) Difficulty in taxiing.

Several less obvious, but serious effects, are:

(1) The loose material removed may remain on the pavement surface to cause "rock bruise" damage to tires or be aspirated into the air intakes of low-slung jet engines.

(2) One case has come to the authors' attention where asphalt pavement, loosened by the jet wake, splattered (in a hot sticky state) on the airplane's horizontal tail surfaces. This causes a cleanliness problem and could conceivably result in particles lodged in the gap between the stabilizer and elevator, restricting control surface movement.

No cases have been reported, to the authors' knowledge, where this loose material, or concrete pavement spalling, has resulted in aircraft skin punctures, but this appears to be a possibility.

Conclusions

The following conclusions may be drawn regarding the effect of aircraft jet-engine wakes on runway surfaces currently in use or soon to be available:

(1) *Effect of Time*—Existing nonafterburning aircraft damage pavement surfaces only when stationary. When afterburning or using jet assistance equipment, damage may occur only when the aircraft are stationary or moving relatively slowly.

(2) *Concrete Pavement*—Existing nonafterburning operational aircraft produce only negligible damage to concrete pavement, and even this damage should be relieved by current paving procedures. Afterburner-equipped jet aircraft may require certain limitations as to location and duration of afterburning to reduce damage to tolerable levels.

(3) *Asphalt Pavement*—Several current operational jet aircraft, not equipped with afterburners, will damage asphalt pavement during stationary operation. Limiting engine operation to partial throttle alleviates this damage only a small amount.

(4) *Unpaved Areas*—No completely satisfactory solution is available for unpaved areas that receive more than occasional use.

(5) *Fires*—Experience has shown that the fire hazard due to jet wakes is negligible.

(6) *Prediction of Damage*—The conditions under which pavement damage may occur can be predicted if the temperature, height-to-diameter ratio, angle of the jet at the nozzle exit, and the temperature tolerance of the pavement are known. Certain combinations of these factors, which may be quite restrictive when afterburning and asphalt pavements are involved, are definitely not tolerable. Recurrent damage probably will be cumulative.

The accuracy of the gas temperature predictions by the methods given here is about ±50°F., due to scatter of the experimental data. Estimates of the tolerable temperatures for various types of pavements in current use are also ±50°F., due to only partially known physical properties. Since 50°F. represents approximately the margins from negligible to appreciable and from appreciable to serious damage, conclusions based on these methods should be used only as a guide.

On the basis of these conclusions, certain recommendations may be made:

(1) Airport pavement should be concrete at all locations where jet aircraft are expected to be stationary with engines operating, while asphalt pavement is optional for taxiways, the center portion of runways,

OPERATING EXPERIENCE WITH JET AIRCRAFT

Aircraft	Engine	Engine Location Configuration	H, In.	α, Deg.	Eff., D, In.	T_j, °F.	Est. T_s, °F.	Meas. T_s or T_z, °F.	Remarks	Ref.
			$3.5D$	0		1,200	199	...	Minimum desirable values for H and α.	10
"Fighter"	...	.....	...	.....	...	...	...	253	On surface of asphalt pavement, no damage. Time not stated.	9
"Bomber"	...	.....	...	.....	...	...	...	385	Maintenance run-up on asphalt pavement, serious erosion.	9
								399	Pavement temperature in asphalt, minor erosion. Time not stated.	..
B-47		Nacelle on strut under wing	...	.....	...	...	...	...	Serious damage to asphalt pavement by outboard engines after 3 min.	9
F7U-1	...	Pair in fuselage	...	7.5 or 13	...	1,274	...	531	Pavement surface temperature after 4 min.	9
F9F-2	...	Single under fuselage	...	3.5	...	1,310	...	410	Pavement surface temperature after 4 min.	9
Avro C102	...	Pairs in wings	...	.....	...	...	...	...	Gouging of asphalt in run up areas.	8

etc. This concrete should contain only suitable, selected aggregate when afterburners are to be used.

(2) Maintenance areas for extended stationary operation of afterburners may require special "blast pits" or water cooling.

(3) Aircraft designers should devote increased attention to the geometrical position of the jet-engine exhaust. Disregard of this factor can lead to increased operating cost. In this connection, it might be added that the Armed Forces apparently have concluded that aircraft performance should not be sacrificed for ground facility limitations.

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The following publications also contain applicable data:

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Porous Metals in Aircraft

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Introduction

HIGH STRUCTURAL STRENGTH porous stainless steel is now in use for aircraft leading-edge anti-icing (or deicing), accomplished by passing hot air through the porous leading edge. Porous bronze has long been used by the British for liquid deicing, and porous stainless steel is now also being used for this purpose. The first really practical test flights of aircraft equipped with porous flap and wing porous flap and wing leading edge for area suction boundary-layer control took place in October of 1953. Transpiration cooling of combustion chamber liners in experimental engines has been successfully accomplished.

Porous metal filters have been used for fuels, lubricating and hydraulic oils, and compressed air; their use will become more widespread as working temperatures increase above 250°F. A Wright Air Development Center contract has been let for development of a 600°F. rated filter.

Porous Metals

Porous stainless steel is manufactured from prealloyed stainless-steel powder (made by a shotting process) by setting down a layer of this material on a ceramic surface, followed by "sintering" accomplished by heating in reducing atmosphere. The currently most used process confines shrinkage during sintering to one direction and yields a porous sheet with favorably anisometric flow properties.[16] Properties of materials with various pore openings are shown in Table 1. These materials are used principally for filtration.

By compressing and resintering these standard materials, materials having lower permeabilities are obtained. If the increase in density accompanying the compression is sufficient, materials of high tensile strengths, up to 50,000 lbs. per sq.in. or more, are obtained. The deicing material described in the next section is made in this manner.

Porous bronze, made by sintering copper-tin or prealloyed bronze powders, without shrinkage, is a somewhat weaker material. Nevertheless, it has seen considerable application in filtration and in aircraft liquid deicing systems. The use of bronze and iron porous bearings is well established. Copper-infiltrated iron powder gas-turbine stator blades have recently become available.

Deicing

In the United States, the use of porous metals for deicing is confined to hot-air deicing on gas-turbine-powered planes, using compressor bleed air. The porous metal is type 316 stainless steel and contains 15 to 20 per cent voids, with tensile strengths in the range 30,000–50,000 lbs. per sq.in.[1] Compared with indirect heating, air requirements are cut one-half, and weight is less due to elimination of double skin and complex ducting. At the temperature of the deicing air, 600°F., it compares not too unfavorably with aluminum on a weight basis, so that a substantial overall weight-saving is realized compared with other available systems.

The properties of a typical porous stainless steel used for deicing are summarized in Table 2, and the flow properties of the wet and dry sheet in Fig. 1. Sheet material of thickness 0.040 in. has been formed to a 0.125-in. radius for an extreme outboard section. Engine intake duct cowlings are readily fabricated. Other hot-air applications not yet actually in production include vortex generators, engine fairings, and control surface deicing.

The workability of this porous material is comparable to that of the high-strength aluminum-alloy sheets commonly used in aircraft construction. The material is attached to aluminum or titanium ribs by riveting, with silicone rubber strip for gasketing. Thickness of material used is in the range 0.030 to 0.040 in., weighing 1.0 to 1.35 lbs. per sq.ft.

The appearance of the deicing material is similar to that of a No. 1 finish solid stainless sheet; the pores average less than 0.001 in. in diameter and are therefore too small to be seen with the naked eye. When enlarged, it is seen that the surface particles are flattened,

TABLE 1

Properties of Porous Stainless-Steel Filter Sheet

Grade	C	E	F	H	X
Mean pore opening, microns	165	35	20	5	15
Minimum tensile strength, lbs. per sq.in.	6,000	15,000	15,000	15,000	25,000
Voids content, per cent	55	50	50	45	20
Minimum flow* of clean air at 1 lb. per sq.in. differential, cu.-ft. per min. per sq.ft.	1,300	340	160	45	6
Minimum flow* of clean water at 1 lb. per sq.in. differential, gal. per min. per sq.ft.	450	52	12	3	2.5

* For a 1/16-in. thick filter.

TABLE 2

Properties of Porous Stainless-Steel Sheet Used for Anti-Icing with 550°F. Air

Average tensile strength	37,000 lbs. per sq.in.
Modulus of elasticity	15×10^6
Thickness range	0.025–0.050 in.
Flow at 2 lbs. per sq.in. differential	40 cu.ft. per min. per sq.ft.
Minimum bend radius	three times thickness

which results in a satisfactorily smooth aerodynamic surface (Fig. 2). It may be "polished" to the equivalent appearance of No. 2 finish or better by light application of a stainless-steel power brush.

It was originally proposed that the porous material be made more permeable at the nose section. Tests showed, however, that the hot air passing through the porous material is effective in preventing icing a considerable distance aft of the leading edge; for this reason, the same uniform flow is provided in currently used materials.

Hot air used for deicing may be available "free" from the compressor of gas-turbine-powered planes, at the correct temperature of 550° to 600°F. Ducting is simplified compared with indirect heating, the hot air being delivered to the inboard end of the plenum that is naturally formed between the forward bulkhead and the leading edge.

An application of the porous material for deicing which has been suggested, but has not yet been put in use, involves the use of a strip of porous material of suitable permeability as external "molding" for the leading edge of aircraft window deicing systems. When a slot is used, a large plenum is required behind the slot to obtain even discharge of hot air. With a porous facing substituted for the slot, a small plenum will provide satisfactory distribution.

Deicing in which porous metal panels are used to distribute a liquid has been practiced in England for a number of years. Compared with releasing liquid from a slot, a 50 per cent reduction in liquid flow is achieved, while obtaining equally efficient deicing.[1] More recently, porous stainless steel has been supplied for this purpose; because of the greater strength of this material, a weight reduction of 60 per cent is experienced compared with porous bronze.

It seems probable that because of its weight-saving features, the porous material will be adopted more and more widely with time. Choice between the hot-air or liquid systems may be dictated by such considerations as whether compressor bleed air is available and other design criteria that will vary from plane to plane.

Boundary-Layer Control

The need for improving low-speed flight characteristics of today's high wing loading airplanes has led to an intensive development program involving many phases of activity. One of the most hopeful approaches involves the use of area suction to prevent separation of the boundary layer at speeds in the range of those used for landing and take-off. A test plane incorporating the boundary-layer material on the leading edge of the wing, as well as one with the boundary-layer material on the leading edge of the wing flap, is being flown at present. Results obtained with these planes, which will supplement those already available from wind-tunnel tests, may be published by the NACA during 1954. Results obtained to date have been most encouraging,

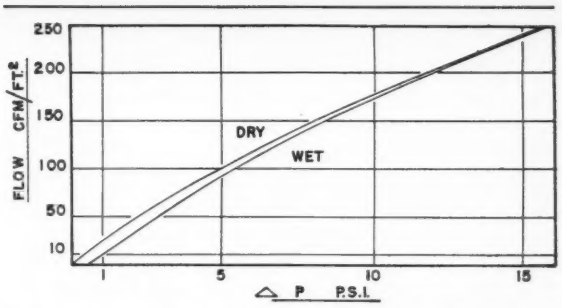

FIG. 1. Flow capacity of porous stainless steel for hot-air anti-icing.

and, for this reason, the use of porous materials for boundary-layer control is planned on several aircraft.

Not the least important phase of this problem has been the development of a porous material that will pass air at high velocity and low pressure drop and, at the same time, possesses adequate mechanical strength, workability, and corrosion resistance, all without excessive sacrifice of weight. Many materials and systems have been used.[4–11] Porous stainless steel has been the material most used for this purpose in recent experimental airplanes.[2]

The range of suction rate is about 4 to 15 ft. per sec. Suction areas for interceptor aircraft are expected to be in the range of 3 to 8 sq.ft. Suction heads range between 300 to 600 lbs. per sq.ft. The corresponding power requirements have tended to militate against application of this system. In order to minimize power requirements, experimental leading edges have been successfully fabricated with very close control of permeability and with permeability varied in a controlled manner both spanwise and chordwise. The variable permeability compensates for variations in ambient external pressures. A typical set of curves showing chordwise variation is shown in Fig. 3. Compared with using a panel of uniform permeability having air per-

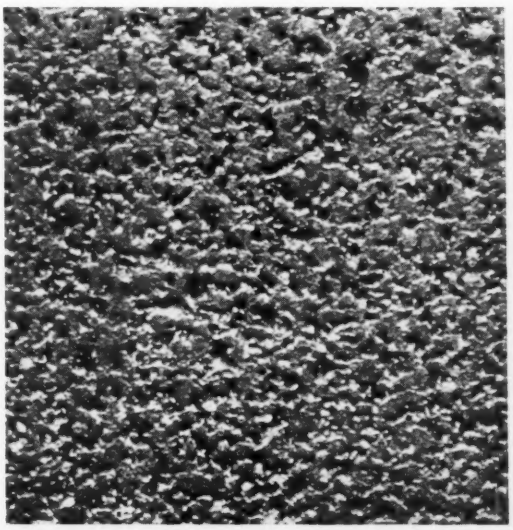

FIG. 2. Surface of deicing sheet, 44X.

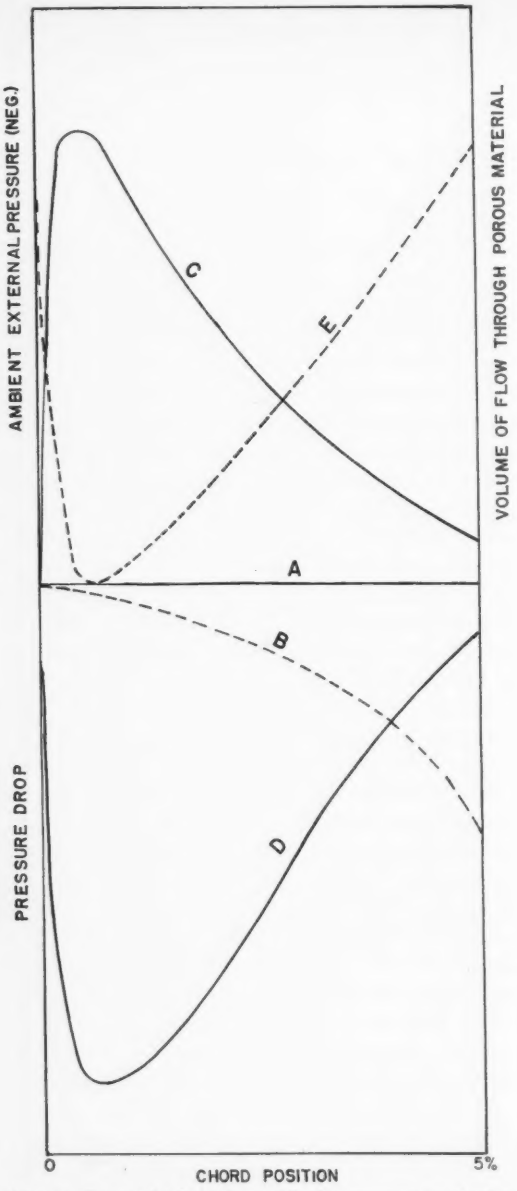

FIG. 3. Curve "A" (a horizontal line) represents the distribution of intake velocities relative to chord location, which is considered to be desirable by most current workers. Curve "C" represents the variation of external ambient pressure, and Curve "D" the corresponding pressure drop variation (measured at constant flow) of the porous material. Curve "B" represents type of distribution of flow velocity which may eventually prove to be more desirable than "A" and will represent a small further economy in power requirements. Curve "E" represents variation during flight of flow volume with chord position when a porous material of uniform permeability is used. Power requirements for configuration "E" are generally more than twice those for configuration "A."

meability of 8 ft. per sec. at 50 lbs. per sq.ft. differential pressure, the following power economies may be achieved:

(a) By using controlled permeability, varying in the chordwise direction only, about 50 per cent reduction in power is obtained.

(b) By using controlled spanwise variation, 10 per cent reduction may result.

(c) By increasing the maximum permeability to 8 ft. per sec. at 20 lbs. per sq.ft., 10 per cent reduction would be possible.

Improvements (a) and (b) are already commercially available. The resulting range of horsepower on interceptor and tactical attack planes is about 10 to 60 hp.

The above power estimates are based on wind-tunnel tests. Initial flight-test results have indicated that only a fraction of the power initially thought to be needed may actually be required.

Controlled permeability variation is accomplished by depositing stainless-steel powder in a manner that deposits more powder in the areas that are to have less flow capacity. This is sintered and coined to uniform thickness, whereby parts of the sheet are made denser and, therefore, less permeable than others. After resintering (annealing), the sheet is finished. The tensile strength of a sheet made in this manner varies in accordance with the permeability; Fig. 4 shows a chart indicating the strength obtained for materials of various permeabilities. Development work now in progress is expected to yield tensile strengths for equal permeability considerably higher than the present maximum curve.

Leaders in the field of compressor manufacture have produced specifically for this purpose an extremely efficient lightweight turbine unit driven by compressor bleed air, as well as another type that is provided with its own independent gas-turbine engine drive, which can be located to minimize duct weight and duct pressure losses.

The extent to which this material will be used for boundary-layer control will depend upon the results obtained in actual flight tests and depends specifically upon such factors as flight characteristics actually obtained, actual decrease in landing speed (or increase in lift), frequency of clogging due to dirt intake, etc.

In installations contemplated at the present time, the material will be manufactured with the most efficient controlled variation of permeability, formed to the wing contour, and drilled and countersunk to be held into place by means of screws. It is hoped that clogging (which may be most severe on dusty airfields when one plane takes off immediately after another) will not result in excessive maintenance. Nevertheless, the possibility of carrying spares and replacing these panels in the same way as one would tires may be contemplated as a practical possibility.

Considerations based upon experience gained in using porous stainless steel for dust filtration indicate that clogging will probably not be a major problem. Where boundary-layer control is used to obtain increased lift, partial clogging of the porous section of the airfoil will not change the flight characteristics at the time of landing and take-off. Even quite a serious clogging—e.g., reduction of 50 per cent in flow capacity—will reduce by only a few miles per hour the point at which separation of the boundary layer occurs.

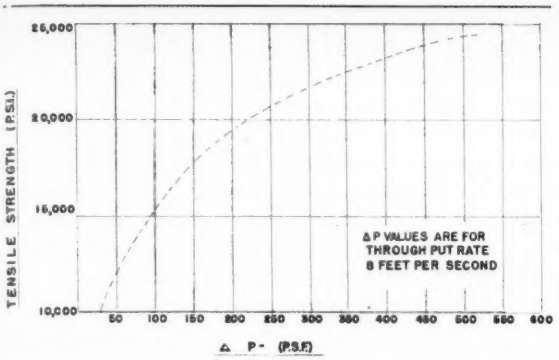
25,000
20,000
15,000
10,000
TENSILE STRENGTH (P.S.I.)
ΔP VALUES ARE FOR THROUGH PUT RATE 8 FEET PER SECOND
50 100 150 200 250 300 350 400 450 500 550 600
Δ P- (P.S.F.)

FIG. 4. Porous stainless steel for boundary-layer control, variation of tensile strength with permeability.

The use of the porous material at the leading edge of the aircraft wing results in excessive angles of attack, which in turn cause poor pilot visibility. Furthermore, power requirements appear to be greater than those needed for boundary-layer control of the flap. For this reason, it appears that most future work will be done on the leading edge of the flap rather than on the leading edge of the wing.

TRANSPIRATION COOLING

Cooling of a chamber can be accomplished by passing a liquid or solid over the outer faces of the chamber walls. Alternatively, the coolant gas or liquid may be passed through porous walls (transpiration cooling). Theoretically, transpiration can be as much as 100 times more efficient—i.e., the amount of coolant required can be reduced by a factor of 100 while maintaining the same surface temperatures.

Quantitatively, this effect may be understood when it is considered that the hot gases internal to the chamber in question transfer little or no heat to the walls by radiation; they must actually contact the wall in order to transfer heat to it. If the whole surface is porous and a slow seepage of cool gas maintains a boundary layer through which heat can penetrate only by conduction in a direction countercurrent to coolant gas flow, the rate of transfer to the surface can be cut down to very small proportions.

Tests involving combustion chambers have been performed in one case using a structure made up to venturi shape; in another, by using a simple tube. In the latter instance, in order to fabricate the tube, a piece of porous metal was cut in the form of a 60° trapezoid, which was then rolled up to form a cylinder, with the welded seam at a 30° angle to the axis of the cylinder. Compared with a solid cylinder externally cooled, less than 10 per cent of a same cooling medium (900°F. air) was required to maintain a wall temperature of less than 1,500°F., while the internal temperature was in excess of 3,500°F. Further work now under way points in the direction of larger scale use.

The porous materials used for transpiration cooling may be materials of very high permeability and relatively low tensile strength, similar to those that are used for boundary-layer control. At the other end of the scale, less permeable porous materials having room temperature tensile strengths in excess of 40,000 lbs. per sq.in., made from heat-resisting alloys, are in sight. Still higher room temperature tensile strengths will without doubt be realized, and it indeed appears probable that short-term tensiles of 30,000 lbs. per sq.in. at 1,200°F. may soon be available, constructed of materials such as Haynes-Alloy 25. Much work remains to be done including development of suitable structural methods, further exploration of high-temperature properties, exploration of the distance over which boundary layer persists where solid material is located downstream of the porous insert, etc.

As higher and higher air speeds are realized, uses for this material may appear in the air frame, as well as within the power plant. The possibilities inherent in the use of this material will be apparent to those now confronted with high-temperature problems in missiles; the position of this system relative to indirect cooling by refrigeration will without doubt be clarified within the next few years.

FILTRATION OF HYDROCARBON FUELS

As turbine-driven aircraft fuel controls become more complex and as working temperatures of fuel lines continue to increase, filtration of the fuels becomes a problem of ever increasing severity. At this time, these changes have caused a state of flux with regard to the determination of the best type of filter to use for this purpose. It does not appear likely that paper filters will be suitable for temperatures above about 200–250°F., nor is it clear at this time whether the filtration obtained at lower temperatures is adequate.

A primary and extremely important step toward the solution of this problem involves improved filtration of

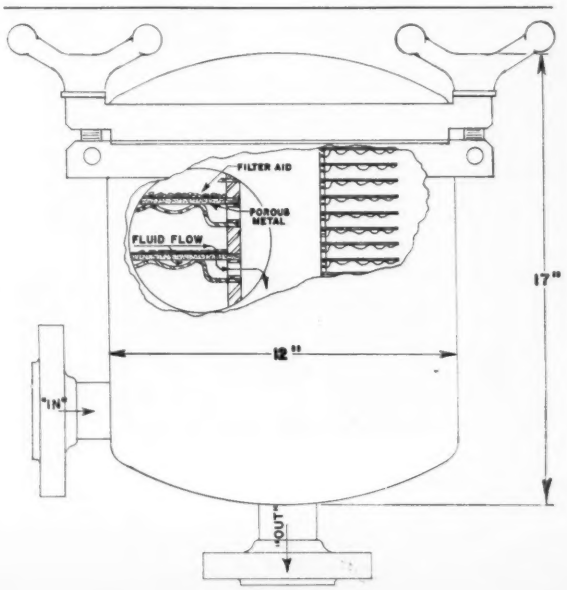

FIG. 5. Fuel filter.

fuel before it is loaded into the aircraft. In tests on a missile where fuel was pumped at 130 gal. per min., a 1-sq.ft. porous stainless-steel filter was found in some instances to develop excessive pressure drop at the end of the filtration cycle. The fuel had been prefiltered prior to use through a paper filter of the type that now meets the AN specifications covering this type of unit. A porous stainless-steel filter (Fig. 5) provided with a precoat of filter-aid was then substituted as a prefilter; subsequent tests showed no perceptible increase in pressure drop during the whole life cycle of the missile! Because the diatomaceous earth that is used to precoat a filter of this kind removes not only gross particles in the 1- to 10-micron range but also the bulk of the colloidal material, clogging of filters is materially reduced, and the filter is then able to perform with much greater efficiency its function of removing casual dirt resident in the system, wear particles generated by pumps, etc. Prefilters of this kind are eminently practical for tank-truck mounting and field maintenance.[3]

Porous metal prefilters have been tried out in the past for use on tank trucks with results leaving much to be desired. These filters were designed with excessively high unit flow rates (about 25 gal. per min. per sq.ft.) and were constructed of porous bronze, which was not necessarily cleanable. It is believed that the present trend will be toward (a) filters having considerably lower ratings (about 5 gal. per min. per sq.ft.); (b) use of diatomaceous earth precoat, which is so much finer than the base metal that supports it that the base metal does not become clogged (at the end of the filtration cycle, the diatomaceous earth is mechanically sluiced off and replaced); and (c) use of stainless steel, which is cleanable regardless of misuse and more flexible in construction. The flexibility of construction with porous stainless steel is such that in spite of the increase in filter area, the overall size of the filter is still rather small; a unit designed for pumping at a 50 gal. per min. rate is shown together with overall dimensions in Fig. 5.

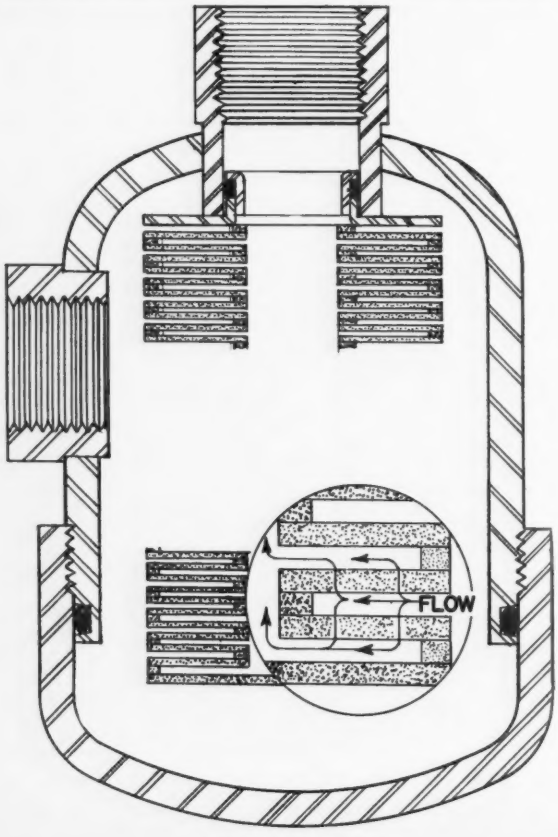

FIG. 6. Hydraulic filter.

The possibility of using air-borne porous metal filters has been greatly promoted by recent developments that permit fabrication of porous material in the range 0.020 to 0.030 in. thick, having a weight of 0.6 to 1 lb. per sq.ft. of filter area. The increased weight of this material over that of paper is partially compensated for by the use of extremely compact designs that may permit a reduction of container size with consequent weight reduction, compared with presently available paper units; 1954 may be a fateful year in determining whether filters of this type will prove to be useful for general fuel filtration application in aircraft.[3]

A second class of filters which may displace the paper units used heretofore are those using porous Kel-F and porous Teflon, fabricated from powder using methods similar to those employed for porous metals. While limited to upper temperatures of 450°F., these units have the advantage of lower weight. Extremely compact designs are available.[14]

The possibility of using filters in tandem and cleaning by backwashing is scheduled to be investigated during the next few months. Certainly a self-cleaning filter is greatly to be desired.

HYDRAULIC OIL FILTRATION

During the past 5 years, the porous stainless-steel filters have shown their worth as hydraulic oil filters in a number of applications, principally in test stands and in critical applications where extremely fine hydraulic oil filtration is required. Filters having capacities of 80 gal. per min. with 2-micron removal and 3,000-lb. per sq.in. service have been supplied and have functioned successfully.[3] For air-borne applications, filter units have been supplied for protection of 0.0001-in. clearance servo-valves, these filters being selected to provide simultaneously the proper damping of frequency response by controlling the pressure drop of the oil through the filter.

A porous metal hydraulic filter air borne for service at a temperature of 600°F. is now being developed. Units that are perfectly satisfactory for temperatures up to 400°F. are already available, and one of these is illustrated in Fig. 6. Those filters intended for high-pressure (3,000 lbs. per sq.in.) service are particularly adaptable to this type of construction, since the decrease in overall filter size compared with paper filters may result in an overall saving of weight.

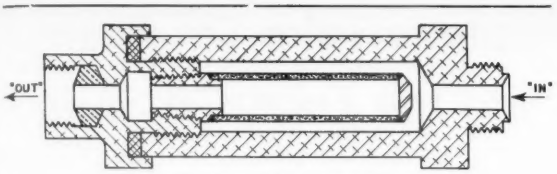

FIG. 7. Breathing oxygen filter.

OTHER FILTRATION APPLICATIONS

Porous metal filters have particular merit for filtration of high-pressure gases; because of the fact that flow through these porous materials is largely viscous, it turns out that extremely large quantities of gas can be successfully filtered by very small filters. Thus, for example, in those areas where excessively high temperatures prevent the use of hydraulic fluids for pressure transmission, air may be successfully used. Another successful application of these porous metal filters is where compressed gases are used for high-speed propulsion of fuels, as in rocket devices. Still another is the filtration of breathing oxygen (Fig. 7).

Lubricating oil filtration may prove to be a suitable application for porous metals; much development work and lengthy testing will be required. This will wait upon the development of a need by power-plant builders.

An interesting field of application for which porous metals have been tried with only moderate success is in the filtration of the various rocket fuels. Porous titanium has been tried for filtration of anhydrous nitric acid, which is extraordinarily corrosive to other metals. Porous Kel-F and porous Teflon have provided a suitable answer for this problem and have also proved to be suitable for hydrogen-peroxide filtration.

MISCELLANEOUS APPLICATIONS

By means of suitable surface treatments involving the use of silicone resin, or of Kel-F or Teflon dispersions, porous metals can be made to be water repellent to the point where a porous metal that will pass gas freely will not pass liquid below a critical pressure. Porous septums that will not pass water at less than 3 lbs. per sq.-in. have been developed. In similar applications, porous materials have been used which will not pass liquid mercury but which pass gases freely, for retaining mercury in manometers and other instruments. In a slightly different application from the use of this material for breather vents, it has been used successfully for holding silica gel in instruments used for the removal of fine water and oil droplets from air; in those, a fine grade of porous metal provides for removal of the droplets, while the silica gel provides the storage capacity, as well as for absorption of oil present in vapor form.

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A Method of Locating the Airplane Take-Off Point and Determining the Take-Off Speed*

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ABSTRACT

This paper presents a method of locating the airplane take-off point and determining the take-off speed. This method has proved useful for those ground-run take-off performance tests that require measurements of the total ground run and the take-off speed. The necessary instrumentation, which is readily installed in the test airplane, consists of an oscillograph, a wheel revolution transmitter, and accelerometers on each main landing gear. The take-off runs are made over small raised strips that are spaced at definite intervals across the runway surface. The strips are permanent, easy to install, and do not affect normal field operation. The take-off point and speed are quickly obtained from the oscillograph record of each run.

INTRODUCTION

MANY TAKE-OFF PERFORMANCE TESTS of land and carrier-based airplanes have as their objective the determination of the ground-run distance required to become air borne and the take-off speed under specified standard conditions. The observed take-off performance must be corrected for the differences between observed and specified conditions. In most cases, stringent time and man-power restrictions dictate the use of the simplest possible test and correction procedures consistent with the required accuracy of results. Therefore, the corrections usually are based on simplified theories,[1, 2, 3] which do not require costly time-histories of the take-off but rather require only measurements of total ground run, ground speed at take-off, ambient conditions, airplane weight, and engine thrust or power. Of these quantities, measurements of the ground run and of the ground speed at take-off are the most difficult and require the most effort because the take-off point, on which both depend, is difficult to determine accurately.

Described in this paper is a method of locating the take-off point and measuring the take-off ground speed. This method has been found by the U.S. Naval Air Test Center to be extremely useful for tests where only the ground run is of interest—e.g., tests of carrier-based airplanes to establish carrier deck length launching requirements and tests of land and carrier-based airplanes to obtain data to compare with estimated characteristics. The method may be used in conjunction with additional instruments, such as theodolite or fixed-grid cameras, for take-off tests where both the ground run and the climb over an obstacle are to be evaluated.

The method described herein requires easily installed oscillograph instrumentation in the test airplane. The instrumentation components are standard, generally available items. The equipment installation time and cost can be further reduced by employing an airplane that already has an oscillograph installed for another purpose, such as for stability and control tests. Take-offs must be made from runways having small raised strips installed across the runway at selected intervals.

In spite of the requirements that instrumentation be installed in the test airplane and that take-offs be made over runways having raised strips, the method has been applied to tests of nine turbojet and propeller-driven airplanes and has been found to be less costly and much faster than previous methods of suitable accuracy used by the U.S. Naval Air Test Center. These other methods have included the use of theodolite, pendulum, and grid cameras to obtain the speed at take-off. The points of take-off have been determined by the consensus of several observers stationed along the runway or the photographic record of lamps on the aircraft which light when the main landing-gear oleos reach full extension.

DESCRIPTION OF THE METHOD

Take-offs are made on a runway with strips across it at definite measured intervals, as shown in Fig. 1. The take-off run is started at a known location along the runway selected such that the airplane leaves the ground after passing over at least two and preferably three strips. The instrumentation installed in the test airplane provides oscillograph time-histories of axial accelerations of each main landing-gear strut and of the revolutions of one wheel, as shown in Fig. 2. There is a displacement of the oscillograph trace for each revolution or, in recent installations, for each half revolution of the wheel. The oscillograph is started before the airplane reaches the first strip and stopped after the airplane leaves the ground. Landing-gear accelerations are present as long as the tires contact the runway surface, and the traces on the oscillograph record indicate the response of the accelerometers to these accelerations. As the wheels pass over each strip, there

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* The opinions expressed herein are those of the authors and do not necessarily reflect the views of the Department of the Navy.

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are large characteristic deflections of the accelerometer traces on the oscillograph record. The instant the wheel leaves the runway, these accelerations sharply diminish and the traces become steady, thereby indicating the point of take-off. This point is shown in the two records in Fig. 2. The slight fluctuation of the accelerometer traces subsequent to take-off is believed due to a slight unbalance of the aircraft wheels. Fig. 2b shows that the wheels actually left the runway for a short distance and then touched down again before the final take-off occurred. Such a record shows an unusable take-off.

The instrumentation is checked for proper operation after each take-off. The oscillograph record is developed and available for analysis less than an hour after the test.

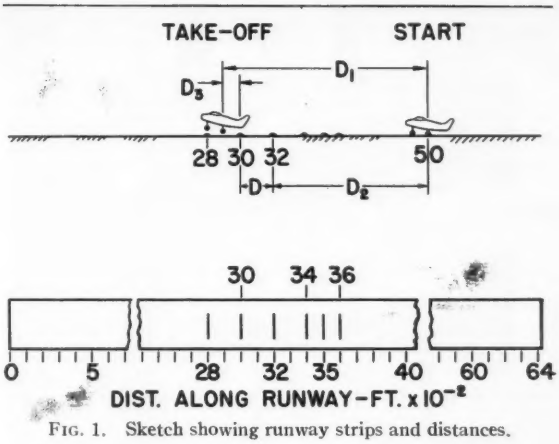


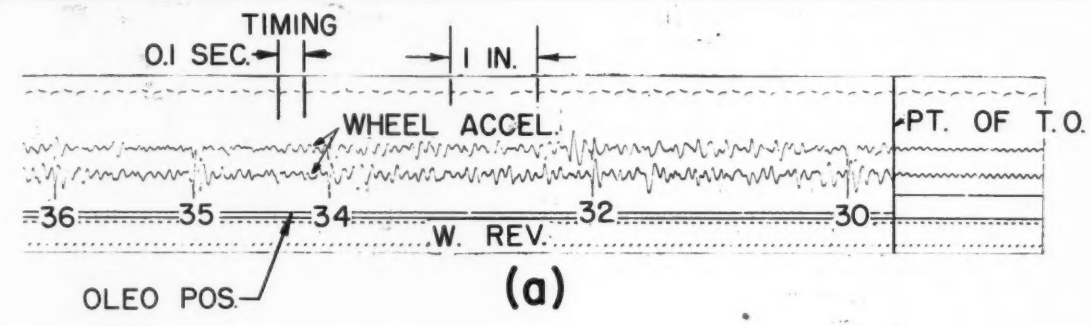
FIG. 1. Sketch showing runway strips and distances.

LOCATION OF THE TAKE-OFF POINT

Although diminishment of the landing-gear acceleration trace hash on the oscillograph record indicates the take-off point, analysis is required to locate the take-off point on the runway.

If the effective circumference of the wheel (ground distance covered per revolution of wheel) is known and the oscillograph is started at the beginning of the ground run, the number of wheel revolutions from the start to the take-off point shown by the accelerometer traces on the record could be multiplied by the effective wheel circumference to obtain the distance from the known start of the run and, thus, determine the point of take-off on the runway. However, tests have shown that the effective wheel circumference varies during the ground run, probably because of distortion of the tire under the varying loads on the tire as the airplane lift changes; a small error in effective circumference could make a large error in distance when multiplied by the many revolutions of the wheel during the run. (For example, an average error as small as 5 per cent effective circumference gives an error of 100 ft. for a take-off distance of 2,000 ft.)

The raised strips across the runway provide definite marks on the oscillograph record at known points during the run to provide (1) an effective circumference calibration of the wheel near the take-off point and (2) a new definite point on the runway closer to the take-off point than the start of the run. The total ground



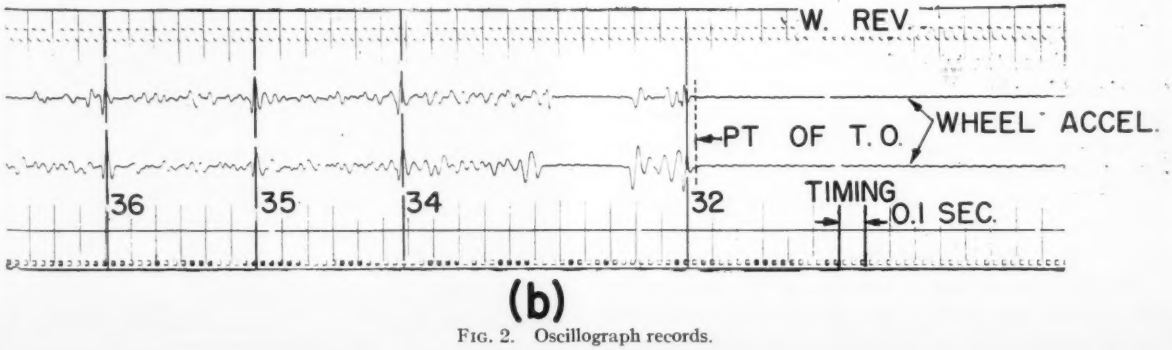


FIG. 2. Oscillograph records.

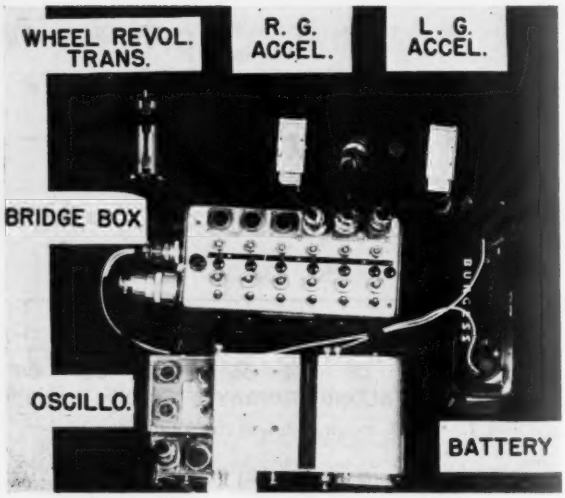


FIG. 3. Components of a typical installation.

run (D_1 in Fig. 1) is composed of the known distance from the start of the take-off run to the raised strip just prior to take-off ($D_2 + D$ in Fig. 1), plus the distance from the raised strip to the take-off point (D_3 in Fig. 1). D_3 is equal to the number of wheel revolutions between the raised strip and the take-off point multiplied by the effective wheel circumference. The effective circumference, C, is equal to the known distance between the two raised strips closest to the take-off point, D, Fig. 1, divided by the number of revolutions of the wheel between the strips. Starting the wheel revolution count at the raised strip just prior to take-off rather than at the start greatly increases the accuracy of determining the take-off point, since (1) the error due to varying effective wheel circumference applies to only that part of the take-off run after the last strip and (2) the effective circumference is more accurately obtained for this interval than for the entire run.

The record of Fig. 2a is reduced as an illustration. The start of the take-off was 5,000 ft. from the end of the runway. First, the effective wheel circumference is computed as the distance between the two strips nearest to the take-off point (they are located at distances 3,200 and 3,000 ft. from one end of the runway), 200 ft., divided by the number of revolutions of the wheel between the two strips, 30.5; the effective circumference is 6.55 ft. Next, the location of the take-off point along the runway is found. The distance from the last strip to the take-off point is equal to the effective circumference, 6.55 ft., multiplied by the number of wheel revolutions between runway station 3,000 and the take-off point, 5.6 revolutions; 37 ft. The take-off point is then 3,000 ft. minus 37 ft. or 2,963 ft. from the end of the runway. Since the take-off run started 5,000 ft. from the end of the runway, the total ground run is 5,000 ft. minus 2,963 ft. or 2,037 ft.

An alternate method of calculating the distance D_3 from the last strip to the take-off point is by multiplying the length on the record between the accelerometer indications denoting these two points by the ratio of the actual distance along the runway between the two strips just prior to take-off to the length on the oscillograph record. For example, in Fig. 2a, the record length from the 3,000-ft. mark to the point of take-off is 0.39 in. The record length corresponding to the distance between the strips at runway stations 3,200 and 3,000 is 2.15 in. The distance traveled by the aircraft beyond the 3,000 ft. mark is therefore $0.39 \times 200/2.15$, or 36 ft., which agrees with the 37 ft. computed with the first method.

The take-off point found by the accelerometers was compared with take-off points located by means of oleo extension limit switches and by means of observers along the runway edge. For example, Fig. 2a has a trace actuated by two oleo microswitches connected in series so that, when both switches were closed, the trace was deflected. These microswitches were installed on the right and left main gear oleos in such a manner as to be actuated at full oleo extension. The record shows that microswitch operation occurred at the point of take-off as indicated by the accelerometers. It was found that the full oleo extension indicated by these microswitches occurred at the take-off point for the more rapid lift-offs. However, on take-off runs where the aircraft wheels skimmed along the runway

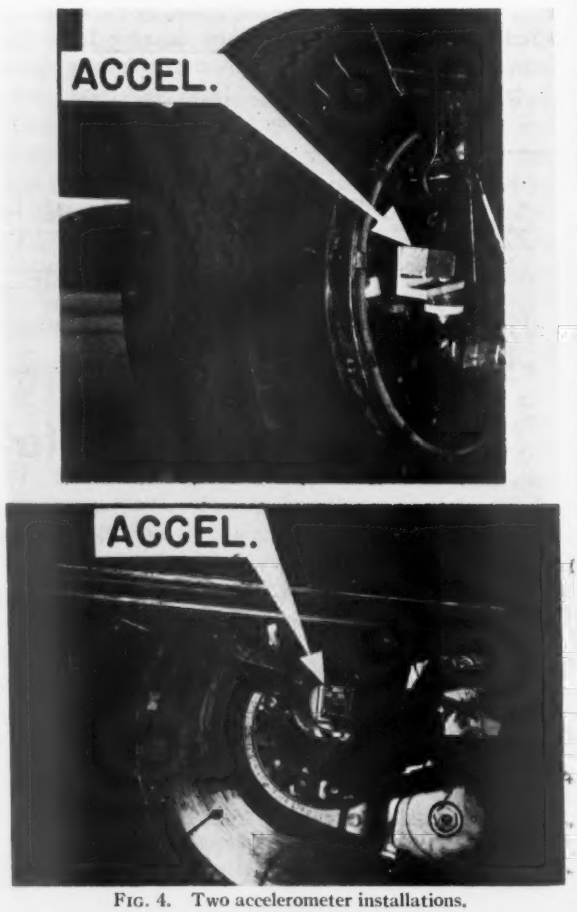


FIG. 4. Two accelerometer installations.

for a considerable distance prior to leaving the ground, the action of the oleo and microswitches was such that the switches would continually cut on and off or would indicate full oleo extension, whereas the accelerometer would show the wheels still in contact with the runway. Take-off points found by observers along the runway agree with take-off points from the accelerometers to within a few feet for sharp take-offs, while the observers' opinions place the take-off point as much as 150 ft. past the accelerometer point for very gradual lift-offs. Since the observers must see light between the wheel and the runway before knowing the wheels are off the ground and since this must occur after the airplane becomes air borne, the accelerometer indication is believed to be more correct.

The Ground Speed at Take-Off

The ground speed at take-off is equal to the effectiv-circumference of the wheel multiplied by the wheel rotae tional speed at take-off. Since it is not possible to obtain the wheel rotational speed at the instant of take-off with the wheel revolution instrument, calculations are based on a wheel rotational speed averaged over a number of revolutions prior to take-off. The equation is

$$V_{to} = (N/t)C$$

where

N = selected number of wheel revolutions prior to take-off, usually 5 to 10
t = time interval for these wheel revolutions
C = effective circumference

The take-off speed is obtained from the record of Fig. 2a to illustrate the procedure. (It should be mentioned that the record of Fig. 2a is an early one and, because of low oscillograph paper speed and timing lines that are not as distinct as desirable, cannot be read as accurately as later records. It is included to show the comparison between the take-off as indicated by the wheel oleo switch and the accelerometers). The effective circumference was obtained previously as 6.55 ft. The take-off ground speed averaged for 10 wheel revolutions just prior to take-off (0.327 sec. recorded time) is

$$V_{to} = 10/0.327 \times 6.55 = 200 \text{ ft. per sec.}$$

The speed computed in the above manner is actually the speed at a point approximately $N/2$ wheel revolutions before the take-off and is generally less than the true take-off speed since the airplane is accelerating. The difference is small and is usually neglected. For example, for the following rather extreme case, $^1/_2g$ acceleration, 150 ft. per sec. take-off speed, 5 ft. effective circumference, and $N = 5$, the computed speed is $^1/_2$ per cent, $^3/_4$ ft. per sec., low. However, if three strips have been crossed prior to take-off, approximate correction can be applied to the speed computed with the preceding equation. The correction is

$$\Delta V = -\left(\frac{V_b - V_a}{L}\right)\left(\frac{N}{2}\right)C$$

where

V_a = the average ground speed between the first two strips just before take-off, D_a divided by t_a
D_a = the distance between the two strips
t_a = the time for aircraft to traverse D_a
V_b, D_b, and t_b = similar values for the second and third runway strips before take-off
L = distance between midpoint of the first and second strips and the midpoint of the second and third strips before take-off

For the take-off of Fig. 2a, the correction is 0.4 knot. In addition to the preceding factor, the accuracy of the ground speed calculation is dependent on the accuracy of measurement of the time increment for N wheel revolutions and the variation in the effective circumference between the last two strips and the average for the wheel revolutions used for the speed calculation. Comparisons of take-off speeds for about 24 take-offs obtained with the instrumentation described herein with those obtained with other methods (photogrid and theodolite camera) show satisfactory agreement.

Equipment

The instrumentation installation in the airplane includes the following:

(1) Oscillograph.
(2) Wheel revolution transmitter.
(3) Two linear accelerometers.
(4) Dry-cell battery.
(5) Bridge balance box.
(6) Pilot's cockpit control and associated wiring.

Typical components are shown in Fig. 3.

The oscillograph is selected on the basis of the maximum timing accuracy and the desired paper speed. It has been found that a paper speed of about 10 in. per sec. and $^1/_{100}$ sec. timing lines give the best compromise between accuracy of fixing the wheel revolution trace blips in time and excessive length of record. The oscillograph is suitably shock-mounted, and its "operate" circuit is wired through a toggle switch in the cockpit.

One linear accelerometer is installed on each main landing-gear strut near the wheel hub with the accelerometer axis parallel to the strut axis. External and internal mountings have been used with equal success. Two installations are shown in Fig. 4. The accelerometers are connected through the bridge balance box to the oscillograph where their output signals are recorded. The accelerometer range has varied between $\pm 10g$ and $\pm 25g$. Best results were obtained when the sensitivity was adjusted to produce a galvanometer trace deflection of about 0.1 in. per g. Accurate cali-

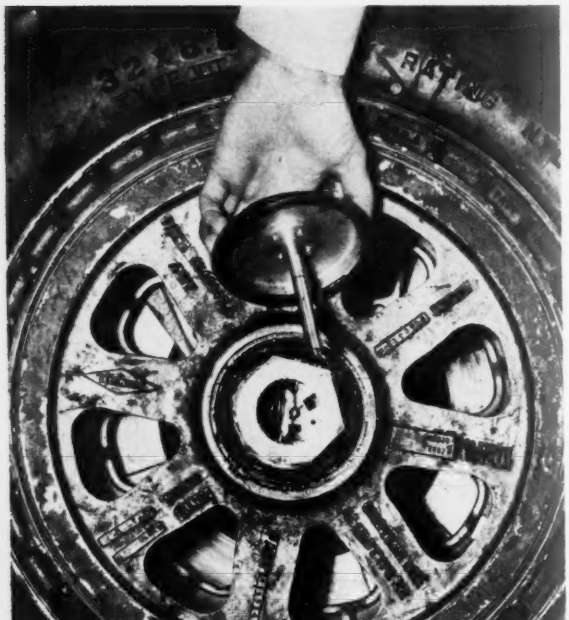


FIG. 5. Typical wheel revolution transmitter.

bration of the accelerometers is unnecessary. As a preliminary check, the airplane with instrumentation operating should be taxied over the raised strips to ensure satisfactory readability of the record.

The wheel revolution transmitter is a rotary switch that completes an electrical circuit once, or preferably twice or more, during each revolution of the wheel. The rotary switch is normally installed internally in one of the main wheel axles, as shown in Fig. 5. In this particular installation, as in most others, the rotary switch is driven by a projecting shaft attached to the inside of the wheel hub cap. The signal from the switch is used to drive one of the oscillograph galvanometers, and the sensitivity of the circuit is normally set to cause $^3/_8$ to $^5/_8$ in. galvanometer trace displacement each time the circuit is closed.

The bridge balance box serves as an intermediate component between the pickup and the oscillograph, providing a convenient means of balancing circuits, adjusting sensitivities, and changing the galvanometer damping. The dry-cell battery serves as bridge power for the accelerometers and as a voltage supply for the wheel revolution rotary switch.

The present strips on the Naval Air Test Center runways are composed of a high-melting-point asphaltic composition. They are 100 ft. long and extend across about one-third of the width of the runway. When initially installed, these strips were approximately 4 in. wide and $^3/_4$ in. high. Aircraft traffic and summer heat have resulted in a flattening of the strips to about $^1/_2$ in. height in a year. Although these strips gave acceptable results, subsequent strips were made of $^3/_4$-in. diameter Manila-hemp line severed at 3-ft. intervals and covered with tar composition to obtain less flattening and a longer useful life. The strips do not interfere with normal field operations.

Concluding Remarks

The method described herein of locating the take-off point and determining the take-off speed of turbojet and propeller-driven airplanes by using oscillographic instrumentation in the airplane and raised strips across the runway has been used by the Naval Air Test Center with good results for ground (or deck) run take-off tests where the climb after take-off was not of interest. It has also been used in conjunction with an airplane attitude angle indicator during preliminary carrier suitability catapult launching tests to obtain the variation of take-off speed and lift coefficient with airplane angle of attack.

Applications of the landing-gear accelerometer component might include: (1) indication of the touch-down point at landing, even though the wheel revolution component probably would not provide accurate ground-speed measurement at landing; (2) indication of take-off or touch-down points on a record where the location on the runway is not important—e.g., for stability and control tests to determine the longitudinal control effectiveness during take-off or landing; and (3) use in conjunction with other equipment, such as theodolite or fixed-grid cameras, for distance-to-clear-obstacle take-off tests where more than generally obtainable take-off point location accuracy is desired.

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The Operational Application of **Automatic Pilots**

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Introduction

The automatic pilot saw its first widespread use as a piece of air-line gear with the advent of the Douglas DC-3 in 1936. This forerunner performed a good job of flying the aircraft and of relieving the pilot of physical control effort during straight cruising flight.

In retrospect, the operational features of this equipment were extremely limited, and by today's standards it would rank as a mere "relief pilot." It did, however, provide a valuable step in the development of present-day equipment.

Its successor, the electronic automatic pilot, brought with it several desirable improvements—namely, improved attitude stability, maneuvering control, and, for the first time, a practical radio-autopilot coupler to provide automatic control during an instrument approach.

This equipment was first placed in scheduled service by United Air Lines in 1946, and its installation has been included on all U.A.L. fleets since placed in service. To date, over a million flying hours have been logged on those aircraft.

The following is a brief account of United Air Lines' equipment status, its performance requirements and maintenance program, and its current utilization of the automatic pilot.

Equipment Program

The general automatic pilot features now considered standard equipment by United Air Lines are:

(1) Basic attitude stability in each control axis.

(2) Magnetic directional control and indication.

(3) Maneuvering control in pitch and turn.

(4) Automatic pitch trim.

(5) Trim indication for each control axis.

(6) Automatic approach control.

(7) Radio navigation control through V.O.R. and V.A.R. facilities (in long-range aircraft such as the DC-6, DC-6B, and DC-7).

(8) Adequate safety interlocks in the power supply and servo engaging system.

(9) Dual electrical "quick release" buttons and a single-lever mechanical disengage.

The scope of these installations with their features is shown on Fig. 1.

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Cockpit Control Features

In addition to the afore-going, considerable importance is attached to the cockpit controls, particularly to the provision of a satisfactory controller. This device, which sets the autopilot in motion and is the channel through which all of its operational phases are governed, might be termed the "coupler" between the human pilot and the autopilot. It must be within convenient reach of the pilot, have simple and direct controls, and a design that provides a control movement suggestive of resultant aircraft response when used for maneuvering. If a pilot's actuations fail to produce the desired response because of such things as awkward design or location, jerky action, lag, or a complicated manipulating procedure, we soon find that he is using the equipment only for straight and level flight and turning it off when maneuvers are necessary, only because he can be more assured of consistent results.

In past experience we have had difficulties with controllers, specifically with regard to their control sensitivity and knob shape. As a result, a number of changes have been required to enable the best maneuvering characteristics of the autopilot to be made available.

Flight personnel have shown preference for the knob and wheel configuration. Further innovations in design will undoubtedly be evolved as we progress in operating experience. (See Figs. 2 and 3.)

Performance Requirements

The general minimum performance requirements that are expected to accompany the operational features in today's typical installation are:

(1) Short-period stability about the roll, pitch, and yaw axes, well-damped but free from sharp corrective action that might be uncomfortable to passengers.

(2) Command control in pitch and turn, permitting smooth and positive aircraft maneuvers to be executed. Turns are to be coordinated at all air speeds.

(3) Directional control within $\pm 1°$ of an established heading.

(4) Barometric altitude control within ± 50 ft. of an established altitude.

(5) Automatic approach control having ability to bracket a standard localizer beam with not more than two overshoots at intercept angles up to 60° at a distance of 10 to 14 miles from the localizer and the ability to hold both localizer and glide slope within ± 20 microamp. deviation of the flight path deviation indicator after the airplane becomes stabilized on both lateral and vertical beams.

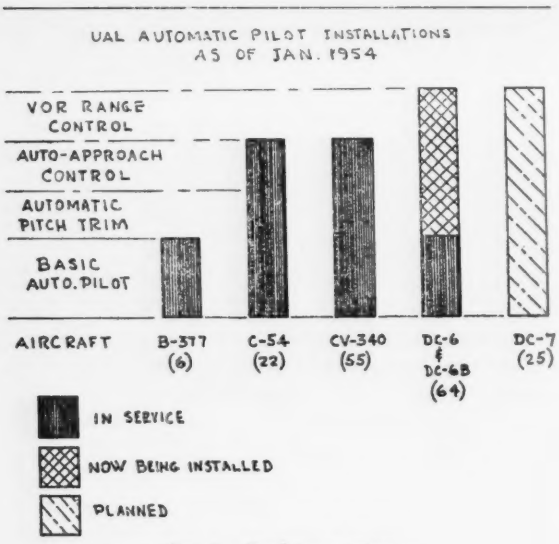

FIG. 1. Equipment status.

(6) Stability on the V.O.R. or V.A.R. range within ±30 microamp. deviation after the aircraft has stabilized on the beam, with stable control when passing over the station's "cone of confusion."

The required performance of an autopilot when installed is usually governed by the intended service application and the capabilities of the available equipment. The operator's efforts can best be shown by setting forth his requirements based on his intended use and past experience with other comparable installations.

Finally, the initial performance achieved is due primarily to the autopilot and air-frame manufacturer's combined efforts.

An example of this cooperation is shown with the CV-340 aircraft. Here, both installation and performance specifications were written by the operator to cover certain air-line requirements. These specifications were reviewed and discussed by all three parties involved, and, after final agreement on all points, the design was installed and tested accordingly. The CV-340 automatic pilot is now realizing a relatively high degree of utilization, and it is believed that this portion of the advance planning played an important part in making it so.

The Maintenance Program

Successful automatic pilot utilization is the outgrowth of its basic performance and its ability to retain this quality during service. Regardless of how excellent the initial performance may be when flying away from the factory, the fact must be faced that current equipment possesses certain items that lack the durability to withstand the rigors of continuous service without the support of an aggressive and effective maintenance program. Moreover, if it is in the class of equipment whose operation is not required for dispatch, the time period during which it is allowed to remain "out of service" must be limited by firm management policy.

Currently, the emphasis is on reliability. Not having the benefit of duplicate installations, the automatic pilot system must stand on its own.

We are now up to a point in performance where we are able to obtain, with a normally operating system, accurate flight control on exact course and at a specified altitude, hour after hour, through either V.F.R. or I.F.R. conditions. Over our destination we can further utilize this relatively high degree of control accuracy during the holding pattern and final approach.

This is the type of operation we would like to consistently achieve between routine maintenance periods. But, if progress is to be gained in the present stage of autopilot development, the operator must recognize the potentiality of a certain percentage of "unpredictable" failures, use the equipment to its fullest extent—with due consideration to safety—and accept the challenge of determining why and when these failures occur and follow through with corrective action. It might be added that adequate service assistance from the manufacturer can also mean a great deal to the operator's success with the equipment. Needless to say, a maintenance organization offers a large contribution to the operational success of an autopilot. In air-line practice, we are concerned with the functions of three general groups—overhaul maintenance, service maintenance, and stores. During maintenance, when components are removed from the aircraft, they are first sent to the repair shop where they are relegated to specialized subgroups equipped to handle the particular work involved. A log is maintained on each unit, and in those cases where a unit has been removed as a result of a suspected malfunction, a record of "shop findings" is forwarded to the engineering analysis group for further evaluation. (See Figs. 4–7.)

Following a final shop inspection, the components are routed to the Stores Department, where they are available for reinstallation or for further transfer to a line station.

During routine aircraft overhaul, certain components are scheduled for replacement, and the remaining portions of the system are inspected and tested. Following the ground test after overhaul, the system must pass a comprehensive flight test, including an automatic approach before it is released for service. (See Fig. 8.)

From here on, until the next aircraft overhaul, the maintenance aspect changes. In service, maintenance personnel must be able to diagnose a system trouble from a pilot's report and make the necessary corrections, and they are usually working against a deadline. Where time does not permit adequate service maintenance, the equipment is rendered temporarily inoperative, until the next check period. At the present there is no infallible method of determining the correct "fix" for every malfunction. Personnel with experience and training, assisted by adequate service manuals and trouble-shooting equipment, have provided the best steps thus far toward the solutions of this problem.

The pulse of daily operation is measured through the medium of aircraft log book reports. These records,

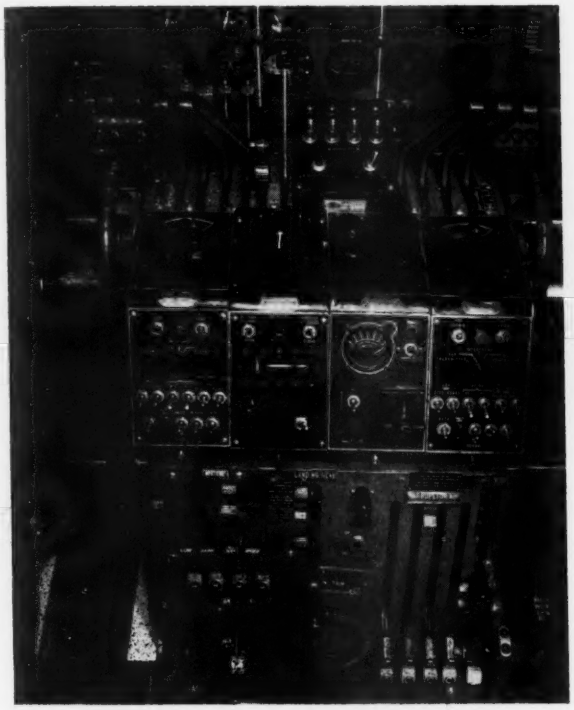

FIG. 2. DC-6 control pedestal showing PB-10A autopilot controller.

FIG. 4. Test stand used in checking calibration of Sperry A-12 compass transmitter.

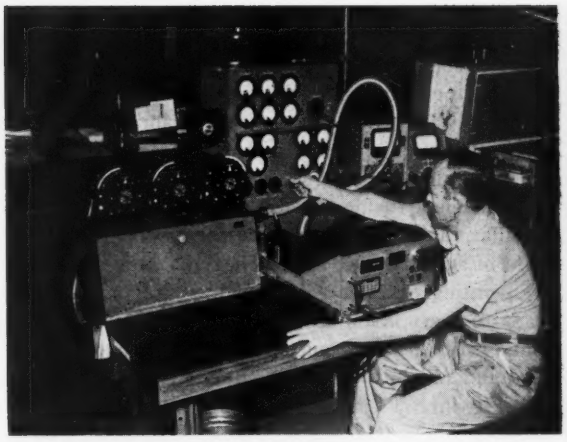

FIG. 5. Test bench used for Eclipse-Pioneer PB-10A amplifier.

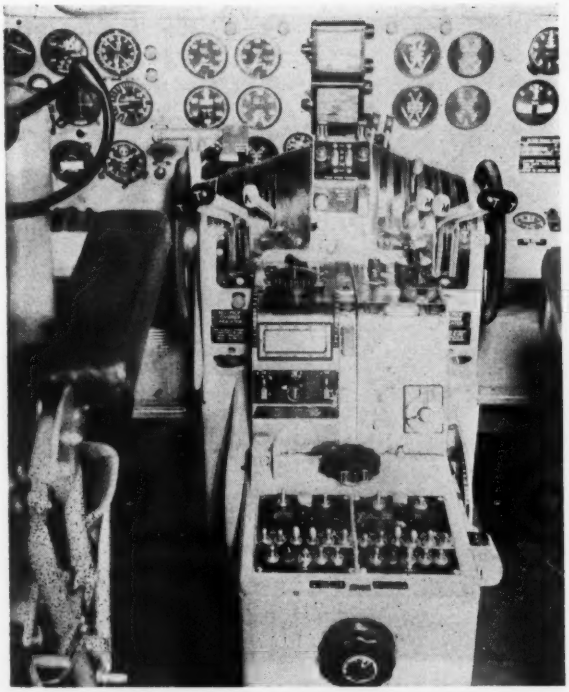

FIG. 3. CV-340 control pedestal showing A-12 controller.

FIG. 6. Testing precession and erection rates of PB-10 vertical gyro.

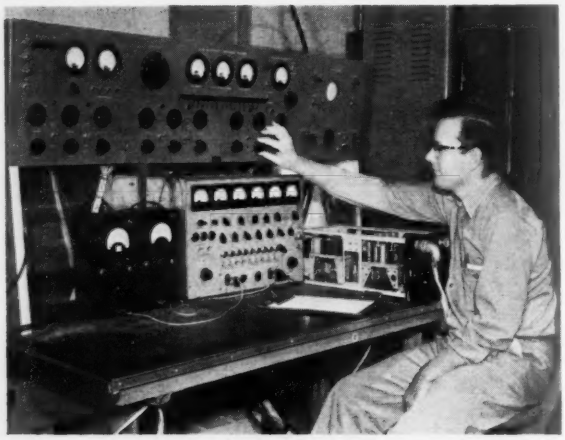

FIG. 7. Bench testing A-12 amplifier assembly at time of overhaul.

combined with unit records received from the overhaul shops, disclose the level of reliability.

When a chronic failure is indicated and corrective action is found to be necessary, the manufacturer's representative is first contacted to determine if a recommended correction is available. After the most desirable action has been determined, an Engineering Change Order is prepared, approved, and scheduled for accomplishment. To date, a total of 115 changes have been accomplished ranging in magnitude from a simple screw change to facilitate a shop adjustment, to the installation of a new coupler to permit the accomplishment of an automatic approach.

Operating experience has resulted in changes being made to every installation and to almost every system component in a continued effort to improve performance and reliability and to reduce maintenance costs. (See Fig. 9.)

UTILIZATION

Seeing all this preparatory design work and maintenance activity being expended to provide automatic flight control, one might begin to wonder what value is to be realized from its use. Is it actually necessary? What returns are to be gained?

True, the autopilot is not mandatory to the accomplishment of a flight. There are many air-line aircraft flying daily without them. Furthermore, it is difficult to see a monetary gain through the use of the autopilot alone.

We do know that it conserves man power—man power that can be further utilized in the higher echelon duty of managing and directing the progress of the flight. We also know that it is capable of providing accurate control over long flight periods through either clear or instrument weather.

When its use is further extended to approach control and it becomes a means of eliminating missed approaches, we can then start calculating its value on a more definite basis.

Perhaps the best way to illustrate the full capabilities of an automatic pilot, both en route and during an approach, is through an example. This particular trip was flown by U.A.L. between Honolulu and San Francisco in a C-54 under military contract. The automatic pilot was utilized during the entire cruising flight of 13 hours on the first leg from Honolulu to the Fairfield-Suisun Air Base. After a holdover at this point, it proceeded to San Francisco, arriving over the field at about 9:00 a.m. Ceiling and visibility at the time were 100 ft. and $^1/_8$ mile, and our trip was scheduled seventh to land. It proceeded to hold for about 45 min. during which time most of the preceding flights had chosen an alternate, thus advancing our trip to No. 2 position. The flight in No. 1 position declined, finally placing our trip in position to land. While holding over the outer marker at 30° to the localizer, clearance was received at 200 ft. and $^1/_2$ mile. The localizer was bracketed, and an automatic approach was completed. Five other trips followed this one, each with a missed approach. No landings were made for 2 hours afterwards.

The automatic pilot was fully and successfully utilized during this flight. It lightened the physical and mental load on the crew, carrying out its intended functions with a relatively high degree of accuracy. And it permitted the flight to be completed at its destination closer to the scheduled time.

The average automatic pilot is available for use about 97 per cent of the flying time of the aircraft. The remaining 3 per cent "out of service" stems from the current maintenance problem previously mentioned.

From the best available estimates obtained from flight personnel, the automatic pilot is used about 90 to

FIG. 8. Glide slope control being tested on ground by means of a glide slope signal generator.

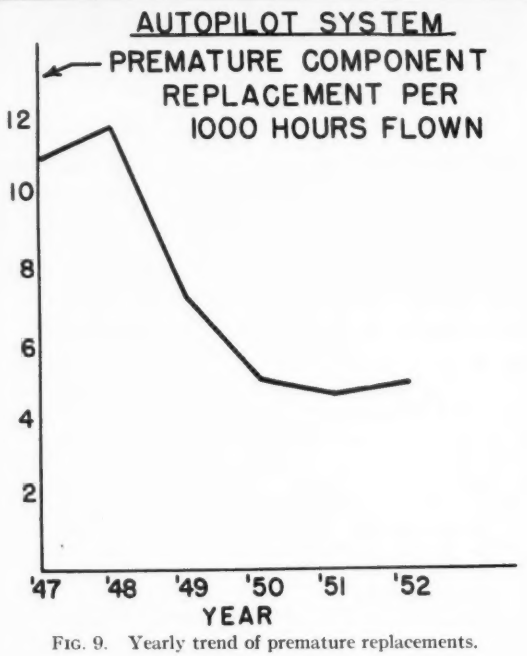

FIG. 9. Yearly trend of premature replacements.

95 per cent of the time on long-range flights. On shorter trips, as with the CV-340, en-route utilization amounts to about 70 or 80 per cent.

Using an automatic pilot in the cruising stage of the flight is simply a matter of placing it in operation, monitoring its actions and changing course or altitude through the controller, as required. During the holding stage, coordinated turns and altitude control are available through controller manipulation.

When the automatic pilot is used with its coupler for automatic approaches, its function changes considerably. Here it assumes the part of a larger overall system. During this stage of the flight, its control functions are guided by radio signals, and these functions then become part of a sequenced flight procedure. Its control accuracy and response can surpass human capabilities in maintaining the aircraft on the beam, but the procedure required in getting it there in the first place is not quite as "automatic" as the term might imply.

Its scope of operation is actually confined within a relatively narrow range, and the technique required on the part of the human pilot to program its functions into the approach procedure at the proper time and under the required flight conditions is of utmost importance to its successful operation. A properly executed automatic approach is the result of a "man-machine" combination.

To illustrate this combination of efforts, let us run through an autoapproach to see just how and where these different controlling factors enter in. (See Fig. 10.) The aircraft, a Convair 340, has been previously prepared for the approach descent conditions approximately 10 to 15 miles out, or prior to leaving the holding point. Final descent items—flaps, power, and gear—are completed prior to intersecting the inbound leg of the localizer.

The autopilot is "on," altitude control "on," and the flight path is controlled by the pilot until the localizer approach leg inbound is being entered. At this point—shown by the localizer needle of the flight path deviation indicator leaving the peg—the pilot may, if he chooses, continue to maneuver the aircraft through the autopilot controller until it becomes established on the beam, or he may move the auto flight selector switch to the localizer position permitting the coupler to accomplish the bracketing. In this maneuver, the coupler limits the bank angle to a maximum of 25°.

After stabilizing on the beam, attitude, altitude, and track continue to be monitored and power is controlled by the pilot to maintain approximately 120 knots.

The path of the aircraft continues on the localizer until just before the intersection of the glide slope—indicated by the glide slope needle being flush with the top of the aircraft body on the flight path deviation indicator. At this point, the altitude control is turned "off," flap settings are increased, and the aircraft's pitch attitude is adjusted to the glide slope by means of the autopilot pitch controller. After glide slope stability is initially achieved, the selector switch is turned to the last position to provide control on both beams. Bank angle is now limited to 10°.

Throttles are adjusted to maintain 105 to 110 knots, and the flight path is monitored through both flight path deviation indicators. Altitude is checked over the outer marker.

If contact is established at or before the minimum altitude, the coupler may continue to be used down to a 200-ft. minimum altitude, as the pilot chooses. At this altitude flaps and engine speed are increased, and the landing is completed.

During an automatic approach, regulations call for the pilot or copilot to have his hand on the control wheel adjacent to the autopilot release button and his feet on the rudder pedals ready to assume manual control at any time.

The autopilot and coupler performance is based on its ability to maneuver the aircraft from the beam edge

(*Continued on page 57*)

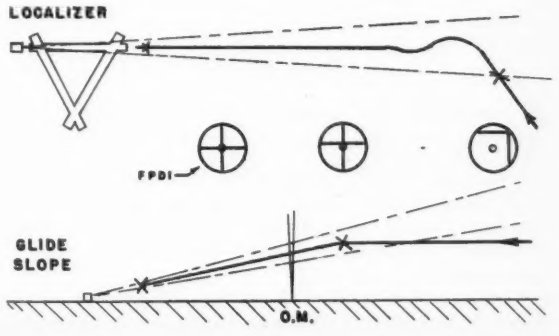

FIG. 10. Approach path.

The Use of Closed-Curve Equations of Variable Degree in Airplane Fuselage Lofting*

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ABSTRACT

The history of lofting practice is reviewed. Requirements for various airplane fuselage types are noted briefly. Some lofting methods now in use are described. The use in lofting of closed-curve, variable-degree equations is suggested. A typical family of fuselages is set up using such equations, and the lofting of one such fuselage using an electronic digital calculator is described. The extension of such procedures to hull lofting is briefly indicated.

LIST OF SYMBOLS

x, y, z = Cartesian coordinates
n, m = exponents or "squareness numbers," not necessarily integers
a, b = constant coefficients, or see below
a = the fuselage maximum half-breadth
b_1 = upper body depth, $F_1(x, a)$
b_2 = lower body depth, $F_2(x, a)$
α = distance from reference point to beginning of midbody, in.
β = distance from reference point to end of midbody, in.
μ = distance from beginning of nose to beginning of midbody, in.
ϕ = distance from end of midbody to end of tail, in.
m_f = squareness number of the nose plan form
m_b = squareness number of the tail plan form
n_1 = squareness number of the upper body cross section, $f_1(x)$
n_2 = squareness number of the lower body cross section, $f_2(x)$
ψ = distance of the plane of the upper and lower body intersection above the longitudinal axis
Δz = the increment of water-line slicing
Δy = the increment of buttock-line slicing
x_i = the stations whose cross sections are to be found
$\overline{Y}_u$ = upper body buttock-line dimensions as found for integral water lines
$\overline{Y}_L$ = lower body buttock-line dimensions as found for integral water lines
$\overline{Z}_u$ = upper body water-line dimensions as found for integral buttock lines
$\overline{Z}_L$ = lower body water-line dimensions as found for integral buttock lines
N = an integer
A = maximum half-breadth in the midbody

INTRODUCTION

LOFTING IS that process whereby the shape of an object is described by means of cross sections defined by various planes cutting the object. The term derives from the practice of laying out large-scale sections of a ship hull on the floor of the sail drying loft. In ship lofting, the practice early arose of defining cross sections by planes perpendicular to the keel. These planes were described as lying a stated distance aft of the bowsprit. The measurement along the keel associated with each plane was commonly referred to as a station. The cross-section diagrams at various stations were used to show the hull outline at that point and could thus be employed as patterns in the construction of the ship's ribs. For each station section, further measurements in height and width of the ship were defined, thus enabling a complete set of specifications to be compiled for the particular hull design. Naturally, the horizontal cutting of each section came to be known as the defining of water lines, and the width of the hull would be given for each integral water-line measurement. From the resemblance of the cross section of early-day ship hulls to the lower part of the human torso (Fig. 1), the measurements lying various integral distances to either side of the keel came to be known as the buttock lines. For each buttock-line measurement, the depth of the hull would be defined.

The deck of the ship was commonly rounded or crowned so that water would run off through the scuppers. The line of uppermost points on the hull thus came to be known as the crown line. The line of lowest points was, of course, the keel line.

The terminology of ship lofting has been carried into airplane fuselage lofting. In the conventional procedure for fuselage lofting a reference point is set up ahead of the nose of the aircraft. Station measurements are made originating at this reference point. Sections are taken at various stations as closely clustered along the fuselage as may be desirable. Where the form of the fuselage cross section is reasonably constant, stations are usually spaced far apart. Where the cross section varies rapidly, as in the vicinity of the pilot's cabin, stations are spaced closely together.

The terminology of water line and buttock line is used in airplane lofting though it has lost its original significance. Each station section is defined in terms of a set of water-line slices and a set of buttock-line slices at right angles to each other. By such means the sides of the fuselage are well defined by the water-line slices, and the top and bottom of the fuselage are defined by the buttock-line slices. In further keeping with ship lofting terminology, the line of lowest points

* The author wishes to acknowledge the work of Malcom O. Post, Evelyn Ratliff, and Irvin Voltin in performing the calculations described herein and the help of Burton Colvin, Robert E. Gaskell, and Randall E. Porter in reading and criticizing the manuscript.

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along the bottom of the fuselage is known as the keel line. The line of highest points along the fuselage is known as the crown line. The maximum width at each station is defined by the measurement known as maximum half-breadth.

As with a ship, the usual fuselage of a conventional airplane is symmetrical in cross section about a vertical plane through the longitudinal axis. Therefore only one side of each station need be defined; the other side will be a mirror image of it.

The Requirements of Fuselage Design

Many requirements need to be satisfied in the design of the typical airplane fuselage. Aerodynamic considerations require that the fuselage shape cause as little drag as possible. If the plane is to be useful in the task for which it was designed, its fuselage will be of a particular size and will be required to carry a given set of loads. Usually these loads will have a certain shape, or set of shapes, not necessarily compatible with aerodynamic considerations. Certain fixed equipment must ordinarily go in the fuselage. Such requirements as these make the selection of a shape for an airplane fuselage a series of compromises. In spite of the sundry uses of different types of conventional airplanes, there is a great similarity in fuselages.

The typical fuselage can often be divided into three parts: first, there is the nose with width increasing with station; then, there is a region of constant cross section; and, finally, there is the tail with width decreasing with station.

The constant-section piece, found in the fuselage of many airplanes, has excellent utilitarian features. The ribs for this region may be fabricated alike. Since the body surface here curves in only one direction, the skin need not be stretch-formed. Also, in the event of a model change, the fuselage may readily be lengthened by the addition of more constant sections.

The Traditional Process of Lofting

In the common procedure of lofting an airplane fuselage, the longitudinal lines are drawn or defined first. The crown line, keel line, maximum half-breadth, and various shoulder lines are defined in plan and profile drawings of the fuselage. These lines may be representations of analytical expressions, or faired-by-eye curves, or combinations of both.

The cross-section plans for various body stations are then usually developed by use of measurements called offsets taken from the plan and profile views.

Many times, a great deal of refitting and cut-and-try must take place before the designer achieves a shape that will satisfy all requirements suitably well. Also, the structures detail designer, faced with the necessity of installing structural members halfway between two stations for which templates exist, must go to a great deal of trouble to approximate the body contours at the exact point of his installation.

Hartley and Liming[1] have set forth a simple and convenient method for employing matching sets of conic sections in fuselage lofting. These conics are found so that they will lie tangent to two lines at given points and will pass through a third point. This method finds wide application.

The Characteristics of Closed-Curve Equations of Variable Degree

Fuselages of circular cross section have certain advantages, particularly in a pressure cabin airplane. The Boeing Model 307 Stratoliner, the first commercial air liner to have a pressure cabin, employed circular cross sections throughout its fuselage.

When utilized for hauling large cubic or rectangular boxes, however, the cabin of circular cross section leaves much wasted space. For best load compressibility, a rectangular cross section like that of the Short Stirling bomber is preferable.

An extremely interesting curve for use as an airplane fuselage cross section is that defined by the equation known as Lamé's special quartic[2] (Fig. 2). This curve represents a compromise between a circle and a square.

If the equation of this general form be restricted to absolute values of the variables, then, any value, whether an integer or not, may be assigned to the exponents, giving a closed curve defined by an equation of the form

$$|x|^n + |y|^n = a^n$$

For $n = 2$, the graph of this equation is a circle of radius a; as $n \to \infty$, it becomes a square of side length $2a$. For values of $n < 2$, the curve of the equation takes on a diamond-shaped form till; at $n = 1$, it is a square of diagonal $2a$. For $n < 1$, it resembles a four-cusped hypocycloid[3] whose equation is, in fact

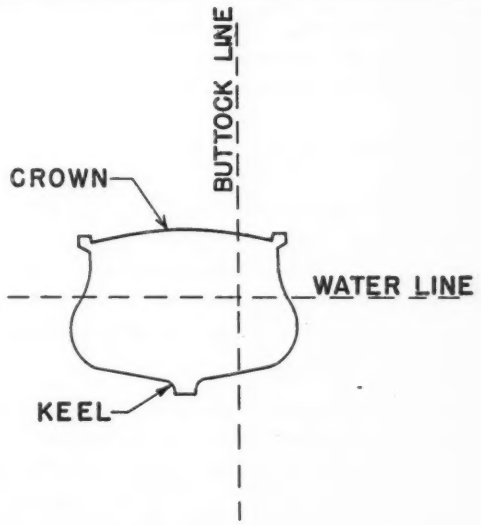

FIG. 1. NOMENCLATURE OF SHIP HULL LOFTING

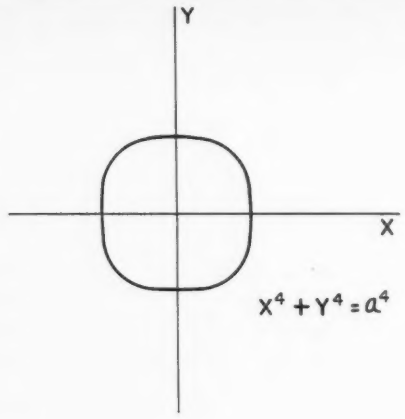

FIG. 2 LAMÉ'S SPECIAL QUARTIC

$$|x|^{2/3} + |y|^{2/3} = a^{2/3}$$

Finally, at $n = 0$, the curve vanishes into the coordinate axes.

In some cases it may be more desirable to approximate a rectangular fuselage cross section with depth, say, greater than width. Here the equation is modified slightly to the form:

$$\left(\frac{|x|}{a}\right)^n + \left(\frac{|y|}{b}\right)^n = 1$$

For $n = 2$, the curve of this equation is, of course, an ellipse. Equations of this general form may be used to represent fuselage cross sections, and the exponent, n, be made to vary as a function of body station. Thus, the designer may change the squareness of the body from station to station. Because of the role it plays in the shape of the curve, the exponent, n, has come to be known as the "squareness number" in application to lofting.

Relationships as Set Up for Lofting a Typical Fuselage Family

A typical family of fuselages was set up for trial calculation in the Engineering Digital Computing Facility of Boeing Airplane Company. This family had the following characteristics:

(1) The fuselage was divided lengthwise into three parts: nose, midbody, and tail.

(2) The maximum half-breadth of the midbody had a constant value, A.

(3) The plan form of maximum half-breadth in the nose and the tail was given by an equation of the form

$$\left(\frac{|x|}{a}\right)^m + \left(\frac{|y|}{b}\right)^m = 1$$

(4) The fuselage was considered to be divided into two sections, upper body and lower body, which sections joined at the maximum half-breadth line.

(5) The upper body cross sections and the lower body cross sections at each station were defined, respectively, by equations of the form

$$\left(\frac{|z|}{a}\right)^n + \left(\frac{|y|}{b}\right)^n = 1$$

where n, a, and b were functions of station.

A rectangular coordinate system was set up with the origin lying a distance $\alpha - \mu$ ahead of the nose point (Fig. 3). The X axis forms the longitudinal axis of the airplane, so stations are defined by their x distance in inches from the origin of the coordinate system, or reference point. The positive direction of the Y axis lies along the left, or port, wing while the Z axis is positive in an upward direction.

The lengths α, μ, β, and ϕ are specified by the designer. He may, for example, make $\alpha = \beta$, eliminating the constant half-breadth mid-section.

Equations of the Typical Fuselage Family

The equations of the curves defining this particular family of fuselages are simply written.

The equation of the nose section plan form (projection in the XY plane) may be written

$$\left(\frac{|a|}{A}\right)^{m_f} + \left(\frac{\alpha - x}{\mu}\right)^{m_f} = 1$$

where m_f is a constant to be specified by the designer. Likewise, the tail plan form is written

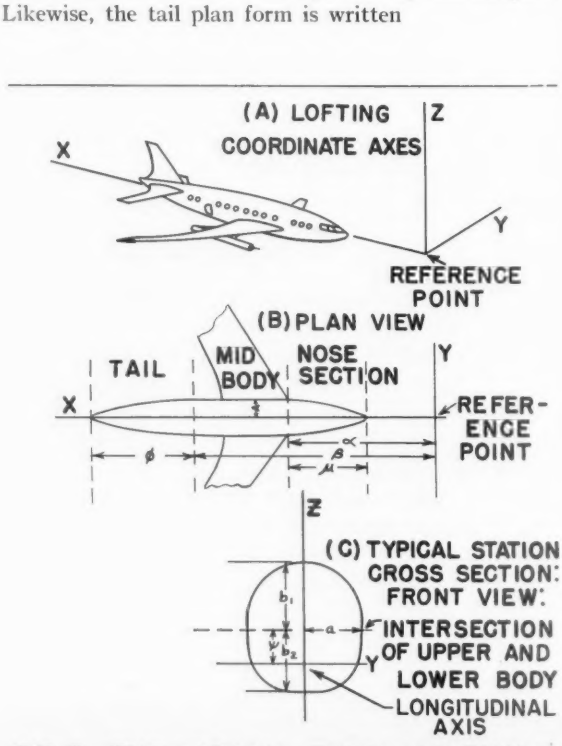

FIG. 3. THE TYPICAL FUSELAGE FAMILY

$$\left(\frac{|a|}{A}\right)^{m_b} + \left(\frac{x-\beta}{\phi}\right)^{m_b} = 1$$

where m_f is a constant.

In Fig. 3C, the typical cross section of the fuselage family is shown. The intersection of upper and lower body (maximum half-breadth line) lies a distance ψ above the X (longitudinal) axis.

The equation of the curve defining the upper body cross section may be written:

$$\left(\frac{|y|}{a}\right)^{n_1} + \left(\frac{|z-\psi|}{b_1}\right)^{n_1} = 1$$

And the corresponding equation for the lower body is

$$\left(\frac{|y|}{a}\right)^{n_2} + \left(\frac{|z+\psi|}{b_2}\right)^{n_2} = 1$$

In both these equations the exponents, n_i, are functions of x as the designer may specify. The upper and lower body depths, b_1 and b_2, may also vary with station as specified.

The designer is given great freedom in developing the members of this fuselage family through the adjusting of these various parameters.

Calculation and Development of Fuselages of the Typical Family

The calculation of water-line and buttock-line intersections for fuselage cross sections represented by closed-curve equations of nonintegral order variable with station is a task forbidding in size when attempted with pencil and paper or with a standard desk-model calculator. Such methods become suitable for practical use only with a large-scale digital calculator.

At the Seattle Division of Boeing Airplane Company, exploratory work of this nature was done employing an International Business Machines Model I Card-Programmed Calculator. It is anticipated that any large-volume lofting of this type will be done on the Model 701 calculator.[4]

Utilizing the electronic calculator, one may readily set up the foregoing equations for solution. The designer must first specify the following parameters and functions: α, β, μ, ϕ, A, m_f, and m_b; constants for each fuselage.

$n_1 = f_1(x)$
$n_2 = f_2(x)$
$b_1 = F_1(x, a)$
$b_2 = F_2(x, a)$
$\psi = G(x)$

(These foregoing functions of station are to be defined for each of the three body sections, nose, midbody, and tail, for each such fuselage.)

Δz = the increment of water-line slicing
Δy = the increment of buttock-line slicing
x_i = the stations whose cross sections are to be developed

The calculator is first instructed to calculate a, the maximum half-breadth, for each required station as follows:

(1) *In the nose* ($x < \alpha$):

$$a = A\left[1 - \left(\frac{\alpha - x}{\mu}\right)^{m_f}\right]^{1/m_f}$$

(2) *In the midbody* ($\alpha \leq x \leq \beta$):

$$a = A$$

(3) *In the tail* ($\beta < x$):

$$a = A\left[1 - \left(\frac{x-\beta}{\phi}\right)^{m_b}\right]^{1/m_b}$$

Next, using a, the buttock-line dimensions for integral water-line slices are found:

(1) *In the upper body:*

$$\bar{Y}_u = a\left[1 - \left(\frac{|z-\psi|}{b_1}\right)^{n_1}\right]^{1/n_1}$$

(2) *In the lower body:*

$$\bar{Y}_L = a\left[1 - \left(\frac{|z+\psi|}{b_2}\right)^{n_2}\right]^{1/n_2}$$

The water-line dimensions for integral buttock-line slices are next found:

(1) *In the upper body:*

$$\bar{Z}_u = \psi + b_1\left[1 - \left(\frac{|y|}{a}\right)^{n_1}\right]^{1/n_1}$$

(2) *In the lower body:*

$$\bar{Z}_L = b_2\left[1 - \left(\frac{|y|}{a}\right)^{n_2}\right]^{1/n_2} - \psi$$

The water-line slices are taken at intervals of $N\Delta z$ (N = any integer) above and below the x (longitudinal) axis. Thus, if $\psi \neq 0$, the maximum half-breadth plane, which defines the intersection of upper and lower body, is not necessarily on a computed water line. In the upper body, the water-line arguments are bounded by the conditions

$$[\psi < z \leq (b_1 + \psi)]$$

and, in the lower body, the water-line arguments are bounded by the conditions

$$[(b_2 - \psi) \leq z \leq \psi]$$

A Sample Fuselage of the Typical Family

Fig. 4 shows the nose and tail cross sections of a typical fuselage of this family. This fuselage is 100 ft. in length and 15 ft. wide at the midbody. The design specifications are as follows:

α = 360 in.
β = 840 in.
μ = 300 in.
ϕ = 420 in.
A = 90 in.

$m_f = 2.00$
$m_b = 1.35$
$\Delta Z = 5$ in.
$\Delta Y = 5$ in.

$$n_1 = f_1(x) = 2 + \left(\frac{x + \mu - \alpha}{\mu}\right) \quad \text{for } [x < \alpha]$$
$$= 3 \quad \text{for } [\alpha \leq x \leq \beta]$$
$$= 3 - \left(\frac{x - \beta}{\phi}\right) \quad \text{for } [\beta < x]$$

$$n_2 = f_2(x) = 2 + 5\left[1 - \cos\frac{\pi}{2}\left(\frac{x + \mu - \alpha}{\mu}\right)\right] \quad \text{for } [x < \alpha]$$
$$= 7 \quad \text{for } [\alpha \leq x \leq \beta]$$
$$= 7 - 5\left(\frac{x - \beta}{\phi}\right) \quad \text{for } [\beta < x]$$

$$b_1 = F_1(x, a) = a$$

$$b_2 = F_2(x, a) = a\left[1 + 3\left(\frac{x + \mu - \alpha}{10\mu}\right)\right] \quad \text{for } [x < \alpha]$$
$$= 1.3a \quad \text{for } [\alpha \leq x \leq \beta]$$
$$= a\left[1.3 - 3\left(\frac{x - \beta}{10\phi}\right)\right] \quad \text{for } [\beta < x]$$

$$\psi = G(x) = 0 \quad \text{for } [x < \beta]$$
$$= A - a \quad \text{for } [\beta \leq x]$$

FIG. 4 A SAMPLE FUSELAGE

Curve Matching at the Intersection of Upper and Lower Bodies

Liming[5] has pointed out that for two curves to "match" well at their point of common tangency, their curvatures should be equal, which, in turn, implies that their first and second derivatives, respectively, should be equal. Thus, in the fuselage family given, we should ask that this condition hold at the intersection of upper and lower bodies. That such is the case, for $n > 1$, with equations of the general form

$$\left(\frac{|x|}{a}\right)^n + \left(\frac{|y|}{b}\right)^n = 1$$

is readily shown.

Differentiating once, we obtain

$$\frac{nx^{n-1}}{a^n} + \frac{ny^{n-1}y'}{b^n} = 0 \tag{1}$$

From whence is gotten

$$y' = -\left(\frac{b}{a}\right)^n \left(\frac{x}{y}\right)^{n-1} \tag{2}$$

Differentiating Eq. (1) again we obtain

$$\frac{n(n-1)x^{n-2}}{a^n} + \frac{n(n-1)y^{n-2}(y')^2 + ny^{n-1}y''}{b^n} = 0 \tag{3}$$

This may be simplified thus:

$$\frac{y^{n-1}y''}{b^n} = (1 - n)\left[\frac{x^{n-2}}{a^n} + \frac{y^{n-2}(y')^2}{b^n}\right] \tag{4}$$

Substituting

$$(y')^2 = \left(\frac{b}{a}\right)^{2n} \left(\frac{x}{y}\right)^{2n-2}$$

In Eq. (4) we get

$$\frac{y^{n-1}y''}{b^n} = (1 - n)\left[\frac{x^{n-2}}{a^n} + \frac{b^n x^{2n-2} y^{-n}}{a^{2n}}\right] \tag{5}$$

Or, solving for y'':

$$y'' = (1 - n)\left(\frac{b}{a}\right)^n \left[\frac{x^{n-2}}{y^{n-1}} + \frac{b^n x^{2n-2}}{a^n y^{2n-1}}\right] \tag{6}$$

Finally, factoring the expression in brackets on the right yields:

$$y'' = (1 - n)\left(\frac{b}{a}\right)^n \left(\frac{x^{n-2}}{y^{n-1}}\right)\left[1 + \left(\frac{bx}{ay}\right)^n\right] \tag{7}$$

At the intersection of upper and lower body we have in every case the condition

$$|x| = a, \quad y = 0$$

Substituting these values into Eqs. (2) and (7) we obtain

$$\begin{vmatrix} y' \\ y'' \end{vmatrix} = \infty$$

for any $n > 1$.

The Use of Closed-Curve Equations of Nonmatching Degree

More generality may be lent to the lofting procedures described herein by use of equations of the form:

$$(|x|/a)^n + (|y|/b)^m = 1$$

where, in general, $m \neq n$. By proper choice of these two exponents, we may obtain reversing curves (see Fig. 5) which are particularly valuable in seaplane hull design.

Concluding Remarks

It is apparently feasible, using equations of the type indicated, to describe an entire airplane fuselage mathematically. The designer is given great freedom in shaping the respective station cross sections through specifying the manner in which the coefficients and exponents of the equations will vary with station. A large-scale digital calculator is extremely useful in this type of work.

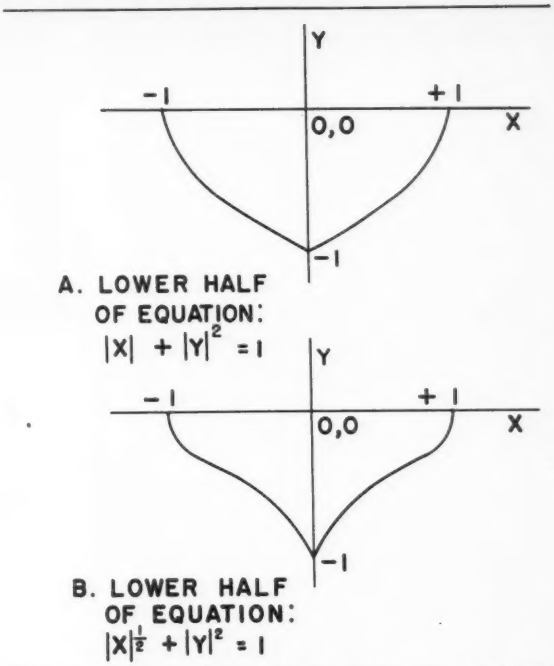

FIG. 5. EQUATIONS OF NON-MATCHING DEGREE

References

[1] Hartley, Carter M., and Liming, Roy A., *Mathematical Technique of Lofting*, International Textbook Company, Scranton, Pa., 1943.

[2] Sisam, Charles H., *Analytic Geometry*, p. 143; Henry Holt & Co., New York, 1936.

[3] *Ibid.*, p. 175.

[4] Buchholz, Werner, *The System Design of the IBM Type 701 Computer*, Proceedings of the IRE, Vol. 41, No. 10, p. 1262, October, 1953.

[5] Liming, Roy A., *Practical Analytic Geometry with Applications to Aircraft*, Chapter XI; The Macmillan Company, New York, 1944.

The Operational Application of Automatic Pilots

(*Continued from page 51*)

to the beam center and from there on to "keep the needles centered." Beam accuracy and stability next govern the path of the aircraft. Pilot's judgment, technique, and timing govern the overall procedure.

The number of automatic approaches made in service is relatively small compared with the number of flights during which the autopilot alone is used. Best estimates indicate that it is used in about 10 to 15 per cent of approaches in both V.F.R. and I.F.R. conditions. This seemingly conservative utilization lies in the fact that the present status of the autoapproach coupler is that of a supplementary control device. The manually controlled instrument approach remains the primary method in today's operation, and the pilot's aim, therefore, is to make the majority of approaches in this manner to maintain the required level of proficiency. Practice in autoapproach procedures is expected to gain impetus in the near future. This will be brought about by the new synthetic flight trainers now being placed in use. Although these devices do not presently incorporate autoapproach equipment, their use is expected to permit more actual flight training time.

In summary of this past automatic pilot experience, it is believed that:

(1) The autopilot serves as a means of increasing the efficiency and safety of a flight through its ability to assume constant attitude, altitude, and directional control and to conserve man power.

(2) Automatic approach control provides a potential means of reducing missed approaches and the high economic penalties that result. Control limitations and operating requirements of the autoapproach equipment must be fully recognized if maximum performance is to be obtained.

(3) Reliability must keep pace with performance if increased utilization is to be realized.

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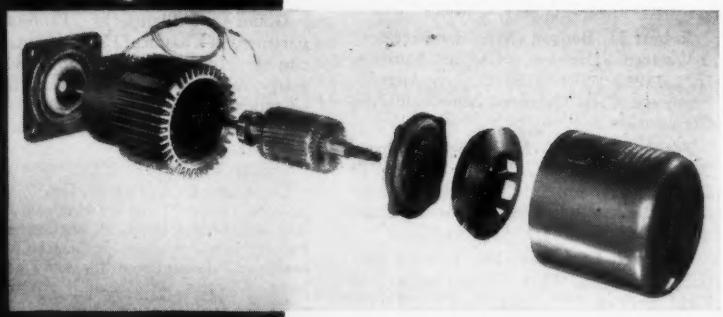

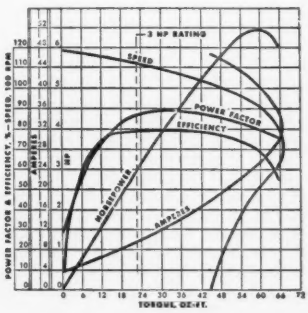

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IAS News

(*Continued from page 23*)

Government grant under the Fulbright Act and a Fellowship by the John Simon Guggenheim Memorial Foundation. Dr. Van Dyke will leave for England in September to spend a year at Cambridge University, where he will engage in theoretical research in fluid mechanics in the Department of Mathematics.

▸ **George H. Woodard** (M) has announced the relocation of the offices of Welling & Woodard, Inc. The new address is 600 York Rd., Jenkintown, Pa. The telephone number is Turner 3454. This firm was formerly located in Philadelphia.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of IAS members. All members are, therefore, urged to notifiy the News Editor of changes as soon as they occur.

Alfred Anthony Adams (M), Sales Engineer, Dayton (Ohio) Zone Office, Allison Division, General Motors Corporation. Formerly, Sales Engineer, Allison, GMC, Indianapolis.

Dr. Antonio Ferri, AFIAS, who has been with the Polytechnic Institute of Brooklyn since 1951, has been named Director of the school's new Aerodynamics Laboratory, Freeport, L.I., N.Y. Two wind tunnels are now being assembled at the laboratory, the first building of which was dedicated on May 8. One of these tunnels is for extremely high temperatures; the other is a hypersonic tunnel being constructed according to a design developed by Dr. Ferri. Brooklyn Poly announced in mid-April that it had contracted to purchase the American Safety Razor Corporation plant in Brooklyn in order to integrate its facilities in one centratly located spot. Inclusion of the Aerodynamics Laboratory in the new Brooklyn acquisition was never contemplated, because of the space requirements of the new laboratory. The Freeport location was selected because of its proximity to the Long Island aeronautical industries.

Ernest W. Fuller, MIAS, recently accepted the position of Manager of REF Manufacturing Corporation's newly established Poly-Plastics Division. Mr. Fuller was formerly Director of Staff Engineering, American Airlines, Inc.

Holt Ashley (M), Associate Professor, Department of Aeronautical Engineering, Massachusetts Institute of Technology. Formerly, Assistant Professor, Department of Aeronautical Engineering, M.I.T.

Dwight H. Bennett (AF), Assistant Chief, Experimental Flight, San Diego Division, Convair Division of General Dynamics Corporation. Formerly, Assistant Project Engineer, Convair.

Robert M. Benson (M), Vice-President—Western Division, Gyromechanisms, Inc., 11941 Wilshire Blvd., Los Angeles. Formerly, Chief Engineer, American Gyro Corporation.

Frank W. Davis (M), Chief Engineer, Fort Worth Division, Convair Division of General Dynamics Corporation. Formerly, Assistant to Vice-President—Engineering, Convair.

Alfred N. Lawrence (M), Eastern District Manager, East Coast Sales and Field Service Organization, Lear Incorporated. Formerly, Contracts Manager, Grand Rapids Division, Lear.

First Lieutenant Robert L. Leff, USAF (TM), Project Engineer, Powerplant Laboratory, Wright Air Development Center, Wright-Patterson AFB, Ohio. Formerly, Second Lieutenant and Graduate Student in Aeronautical Engineering, Air Force Institute of Technology.

Harvey A. Leich (M), with Engineering Department, Columbus Division, North American Aviation, Inc. Formerly, Design Engineer—Arresting Gear, Grumman Aircraft Engineering Corporation.

Jesse G. McFarland (M), Special Projects Design Engineer, Missile Systems Division, Lockheed Aircraft Corporation. Formerly, Administrative Engineer, Mount Lee Laboratory, Stanford Research Institute.

Robert J. Minshall (F), Chairman of the Supervisory Board and Director of Research and Development, Pesco Products Division, Borg-Warner Corporation. Formerly, President and General Manager, Pesco Products Division, Borg-Warner.

Henri C. Nadworny (TM), now with Grumman Aircraft Engineering Corporation. Formerly, Associate Engineer—Structures, Douglas Aircraft Company, Inc.

First Lieutenant Lawrence O. Prestjohn, USAF (TM), Assigned to Far Eastern Air Force (Mail: Box 13, Black Hawk, S.D.). Formerly, Basic Multi-Engine Pilot Training and B-26 Transition-Instrument Training.

Private O. Pruszanowski (TM), 138 Ord. Co., Box 110, White Sands Proving Grounds, N.M. Formerly, Student, Business and Engineering Administration, School of Industrial Management, Massachusetts Institute of Technology.

Robert C. Sellers (AM), General Manager, Defense Operations, CBS-Columbia. Formerly, Washington Representative, The Magnavox Company.

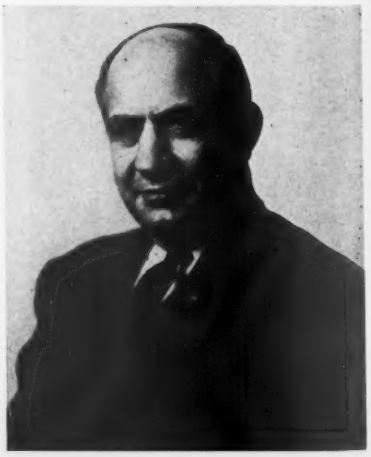
S. R. SenGupta (M), Director, Indian Institute of Technology, Kharagpur, E. Railway, India. Formerly, Principal, Bengal Engineering College, P.O. Botanic Garden, Howrah, West Bengal, India.

Alan H. Stenning (TM), Assistant Professor, Department of Mechanical Engineering, Massachusetts Institute of Technology. Formerly, Instructor, Department of Mechanical Engineering, M.I.T.

Herbert M. Toomey (M), Chief, Civil Aviation Mission, c/o U.S. Embassy, LaPaz, Bolivia. Formerly, Chief, Aircraft Engineering Branch, CAA, New York International Airport, N.Y.

Glenn C. Williams (M), Professor, Department of Chemical Engineering, Massachusetts Institute of Technology. Formerly, Associate Professor, Department of Chemical Engineering, M.I.T.

Dr. Clifford C. Furnas, FIAS, was appointed Chancellor of the University of Buffalo, succeeding Dr. T. R. McConnell. Dr. Furnas, who has been associated with research and development for many years, has been Director of Cornell Aeronautical Laboratory, Inc., since its inception on January 1, 1946. Prior to that, he was Director of Curtiss-Wright Corporation's Research Laboratory in Buffalo, which was given to Cornell University and became Cornell Aeronautical Laboratory.



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Corporate Member News

• **Aerojet-General Corporation, Subsidiary of The General Tire & Rubber Company . . .** According to a recent announcement, Gen. Omar N. Bradley, former Chairman of the Joint Chiefs of Staff, and Rear Adm. Calvin M. Bolster, USN (Ret.), FIAS, Coordinator of Development for The General Tire & Rubber Company and former Chief of Naval Research, have joined the Technical Advisory Board of Aerojet-General. Other members of the Technical Advisory Board are Dr. Theodore von Kármán, HFIAS, Chairman, founder of the company, and its Chief Technical Consultant and Chairman, AGARD, NATO; Dr. Bruce H. Sage, Consultant, and Professor of Chemical Engineering, California Institute of Technology; Dr. Clark B. Millikan, HFIAS, Consultant, and Director, Guggenheim Aeronautical Laboratory and Southern California Cooperative Wind Tunnel, CalTech; and Dr. Fritz Zwicky, Aerojet's Chief Research Consultant. The company is currently producing a variety of sizes of rocket power plants for aircraft and is active in "nearly every missile program in the country."

• **Aluminum Company of America . . .** It was announced on May 17 that two of the four production units of Alcoa's new Chemical Products Plant in Bauxite, Ark., were in operation. The third and fourth units of this Chemical Products Plant are expected to be in operation during the summer. . . . A 54-page two-color booklet, "Research at ALCOA," has been published by the company. This booklet outlines the work of Alcoa's 14 research divisions at three locations and includes a listing of more than 1,000 books, technical papers, and articles prepared by Alcoa research scientists on the subject of aluminum in the last 35 years. Copies of this publication may be obtained from Alcoa Sales Offices or from the company's Pittsburgh office. . . .A 16-page booklet, "Alcoa Impact Fact Book," has been published and is available from the company's Pittsburgh office. This new booklet covers the significant facts necessary to design products as impact extrusions.

• **American Airlines, Inc. . . .** An $8,000,000 maintenance base is being planned for the New York International (Idlewild) Airport. The construction of this base is expected to be completed early in the summer of 1956. . . .Walter H. Johnson, Jr., who became Vice-President—Properties during the company's reorganization earlier this year, has been named Vice-President and Sales Manager of American Airlines.

• **Beech Aircraft Corporation . . .** The modification and production of the Beechcraft Model D18S into a tactical support airplane and armament trainer was recently announced. In its military version, this twin-engined aircraft carries two 0.50-cal. machine guns in the nose and has provisions under the wings for either twelve 2.25-in. rockets or two 100-lb. bombs. A 16-mm. movie camera mounted under the nose may be used as a gun camera or for ascertaining gunnery results. All modifications are external, and all armament controls in the cockpit are so located that they do not disturb the normal layout of the instrument panel. Hence, the entire cabin can be used in normal transport, photographic, or training operations. The first production model of "militarized" Model D18S was delivered this spring to the Chilean Air Force.

• **Boeing Airplane Company . . .** It was announced on April 27 that Boeing's transport-tanker prototype would be rolled out of the company's Renton, Wash., plant in May and was expected to fly in June—2 months ahead of schedule. [The date of its first flight was delayed until July, as a result of a mishap experienced during taxi tests on May 21.] This airplane is being built as a test and demonstrator model for two potential versions: a military tanker-transport to be known as the Jet Stratotanker and a commercial air liner to be known as the Jet Stratoliner. For further information on this Boeing prototype, please refer to the April, 1954, issue of the AERONAUTICAL ENGINEERING REVIEW—the cover picture and its caption on page 3 and the picture and caption on page 84.

• **Canadair Limited . . .** The one-thousandth F-86 Sabre built by Canadair under license was delivered to the Royal Canadian Air Force on April 20.

• **The Cessna Aircraft Company . . .** Two Cessna prototypes are reported about ready to make their maiden flights. These are the CH-1 four-place helicopter and the XT-37 two-place trainer powered by two Continental Marbore 352 jet engines rated at 900 lbs. thrust each. The first flights of these prototypes are scheduled for the early part of the summer for the CH-1 and in August for the XT-37.

• **Convair Division of General Dynamics Corporation . . .** A solar furnace, believed by Convair to be the largest one in this country, is now being used by the company's San Diego Division to study various metals and ceramic materials in connection with several research projects. The basic part of this solar furnace is a 120-in. diameter polished-aluminum mirror formed into a parabolic reflector. Made of 0.25-in. aluminum, the reflector draws its power from the sun. The sun's rays collected by the mirror are reflected to a focal point, forming a $^{5}/_{16}$-in. diameter image of the sun at a distance of 34 in. from the center of the mirror. Materials being tested are held by metal jaws at this focal point. When sky conditions are ideal, the furnace can develop a temperature of 8,500°F., approximately 85 per cent of the temperature of the sun's surface. In order to keep the focal spot in one location on the specimen, the mirror is mounted on a gimbal ring so that the polar axis of the mounting is parallel to that of the earth's. A clock mechanism, driven by a synchronous motor, coordinates movement of the mirror with that of the sun, thus permitting extended experiments with the furnace. Sky haze and clouds greatly reduce the efficiency of the furnace. To secure optimum performance of the furnace, Convair reportedly plans to move the equipment from San Diego to a nearby mountain top where sky conditions are "ideal." . . . The YC-131C, the twin-engined turboprop military transport, has been given the name "Turboliner." The YC-131C Turboliner is Convair's Model 340 Convair-Liner equipped with YT-56 Allison engines. . . . On April 29, the shareholders of Convair and General Dynamics Corporation voted to merge the former company into the latter one. This action had been agreed upon by the Directors of both companies on March 1. Convair, now operating as a Division of General Dynamics, retains its name, individual identity, and organizational structure. The Boards of Directors of the two corporations have combined to make a new General Dynamics Board of Directors, which held its first meeting on April 30. John Jay Hopkins, President of General Dynamics, is Chairman of the Board. All Convair officers continue in their various positions, with Convair's President, Gen. Joseph T. McNarney, also becoming a Senior Vice-President of General Dynamics.

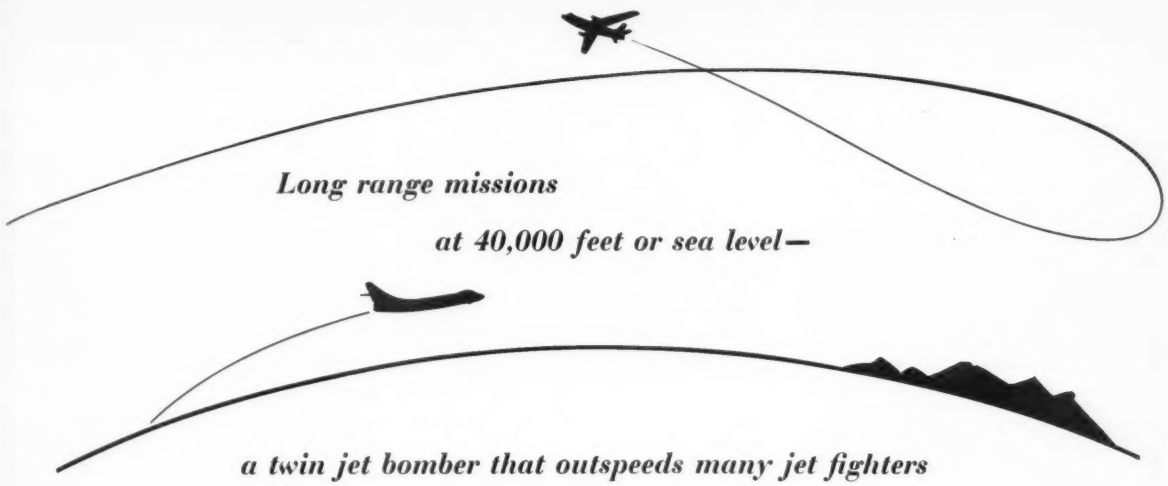
• **Curtiss-Wright Corporation . . .** An $800,000 Dehmel DC-6B Flight Simulator has been ordered from Curtiss-Wright by Swissair, the air line of Switzerland. When delivered, the simulator will be housed in a new building specially constructed for it at Swissair's base at Kloten Airport, Zurich.

• **Douglas Aircraft Company, Inc. . . .** A. M. Rochlen, Director of Public Relations, and K. G. Farrar, General Manager of the Long Beach Plant, were recently elected Vice-Presidents of the company.

• **Eaton Manufacturing Company . . .** A new division, known as the Aircraft Division, has been established by Eaton. John F. Romans has been appointed General Manager of this operation, located in Battle Creek, Mich.

• **Fairchild Camera & Instrument Corporation . . .** A new rectilinear-type potentiometer, designated Type 910, has been developed by Fairchild's Potentiometer Division. According to a company release, dual resistance elements, various stroke lengths, double shaft extensions, room for internal fixed resistors, and various methods of actuating are all variations of a single basic design.

• **Fletcher Aviation Corporation . . .** The Fletcher Foundation has been established by Fletcher Aviation as a nonprofit corporation for the encouragement of scientific, educational, and research activities. Its basic purpose, it is said, is "to encourage schools, research groups, and individuals toward further study and development in various fields of the arts and sciences as they relate to the American system of free enterprise." A number of loans and scholarships have already been granted to students. Various scientific and educational projects designed to stimulate interest and creative thought in several industrial and academic fields are under consideration by the Foundation. . . . The election of Gen. John K. Cannon, USAF (Ret.), as Chairman of the Board of Fletcher Aviation and the appointment of Major Gen. Leroy H. Watson as Assistant to Fletcher's President were recently announced. General Cannon, former Commander of the U.S.



Long range missions

at 40,000 feet or sea level—

a twin jet bomber that outspeeds many jet fighters

—the U. S. Navy's Douglas A3D

Compact in design, outstanding for its work-weight ratio, the carrier-based twin jet A3D typifies a Douglas-led trend toward less complex combat aircraft.

Simplification, which gives A3D greater speed, range, and payload than any comparable bomber, also results in great versatility. The Douglas A3D can fly high-altitude attack missions or serve as a mine layer. Largest of all carrier-based aircraft, it can handle—in its internal bomb bay—the bulkiest bombs, torpedoes, or other naval munitions designated for carrier action.

Design of A3D is another example of Douglas leadership in aviation. Developing planes that can fly *faster and farther with a bigger payload* is a basic Douglas concept.

Be a Naval flier—write to Nav Cad, Washington 25, D. C.

Depend on *DOUGLAS* **First in Aviation**

Air Forces in Europe, recently retired after 37 years of service. General Watson, who recently concluded a 38-year military career, was Postwar Coordinator of the U.S. and Japanese government military security planning and training for Japan. During the German war crimes trials, General Watson was Commanding General of the Nuremburg Military Enclave.

• **General Electric Company . . .** A new compass system for aircraft has been developed by G-E's Meter and Instrument Department. Designated the MA-1, this new navigational aid is said by company engineers to offer a free-gyro drift rate of less than 4° per hour. It weighs less than 20 lbs. When harnessed or "slaved" to the earth's magnetic field through a modern remotely mounted compass, the system reportedly provides consistently accurate and stabilized heading information in any compass direction. Designed to provide controlled latitude-drift compensation, the MA-1 features a normal "slaving-rate" of about 2° a minute and has a built-in synchro output for operating a radio magnetic indicator, omnirange, and automatic pilot. Additional information on the G-E MA-1 Compass System is contained in Bulletin GEA-5998, which is available by writing G-E's Schenectady, N.Y., office.

• **The B. F. Goodrich Company . . .** William S. Richardson, who had served as Executive Vice-President of the company since 1952, was recently elected President. He succeeds John L. Collyer, who had held this post since 1939. Mr. Collyer continues his association with Goodrich as Chairman of the Board and Chief Executive Officer.

• **Grumman Aircraft Engineering Corporation . . .** A new $20,000,000 plant has been completed by the U.S. Navy for Grumman occupancy. It is located on a 4,500-acre tract of land near Calverton, L.I., N.Y., some 75 miles from Manhattan. It is believed to be the first aircraft plant built solely for jet assembly and flight operation. The plant layout includes an assembly-administration building, a steam heating plant, a paint shop, a flight operations building, hangars, and warehouses. There are two runways, one of them 10,000 ft. long and the other 7,000 ft. long. The electrical system, installed by Broadway Maintenance Corporation, cost about $2,000,000 and involves 3 miles of 66,000-volt transmission line, an outdoor 66,000- to 13,000-volt step-down substation, 13,000-volt switchgear and underground cables, twelve 13,000-volt indoor distribution substations, and all interior wiring for light and power.

• **Jack & Heintz, Inc. . . .** The election of Charles W. Sanford as Vice-President—Manufacturing and John E. Ault, Jr., as Comptroller was recently announced. Mr. Sanford had been Works Manager of Jack & Heintz since early 1953. Mr. Ault was formerly Comptroller at Houdaille-Hershey Corporation.

• **Kollsman Instrument Corporation . . .** An instrument for obtaining accurate measurements of jet-engine performance has been developed. Known as the Kollsman Pressure Ratio Indicator, it indicates the ratio of total engine pressure at the tailpipe and at the inlet and thus tells the pilot if he is getting the best engine efficiency. When air borne, the jet pilot can, by watching a dial, hold a given reading of pressure ratio for most efficient flight. This instrument can be provided with a manually adjustable temperature index, which, when adjusted for the surrounding temperature, shows the exact full-throttle pressure ratio for a particular field altitude. Both direct- and remote-reading units are now available. The direct unit, Model 1985, is self-contained and has the advantage of being lighter. The remote system, Model KS 47, has the basic pressure-measuring mechanism mounted near the engine and is for applications where it is desirable to eliminate tubing. The pressure range can be varied for individual turbojet powerplant requirements. The Kollsman Pressure Ratio Indicator operates accurately for ambient temperatures in the range of from −55° to +70° C. . . . A new Magnetic Amplifier, Type 2063-01, is now being manufactured by Kollsman. This Amplifier, which weighs 15.5 oz., is designed for use in meteorological sensing systems and in aircraft, navigational, gun fire, and other precision automatic controls. The unit is entirely self-contained in a hermetically sealed case measuring $1^{5}/_{16}$ by $3^{1}/_{2}$ by $3^{7}/_{8}$ in. Consisting of two stages of vacuum-tube preamplification and a magnetic power-output stage, the Amplifier operates from a 115-volt, 400-cycle source and requires approximately 14 volt-amperes at a power factor of 0.7. Input impedance is 5,000 ohms, and the maximum time delay is 1/400 of a second.

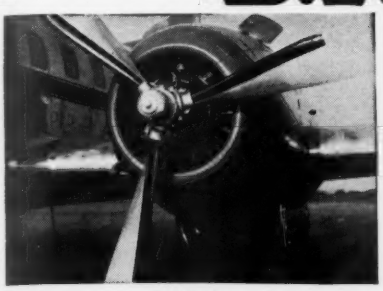
• **Lear Incorporated . . .** The CAA has approved the installation of the Lear L-5 automatic pilot in the Super Constellation. The L-5 is the commercial version of the F-5. . . . A new aircraft screwjack, Model 586, has been developed "to meet the increasing need for a compact light-weight unit capable of high-load actuation while acting as a heavy-duty structural member." This 1.1-lb. unit is said by the company to feature maximum operating loads of 3,500 lbs. compression and 1,200 lbs. tension and to be capable of withstanding static loads of 7,000 lbs. tension and 8,000 lbs. compression without deformation. Operating temperature range is from +250°F. to −65°F. Individual models of the 586 series of screwjacks can be modified to meet special customer requirements. . . . The company's East Coast sales and service facilities have been expanded through the acquisition of a new 5,000-sq.ft. building at 578 Grand Blvd., Westbury, L.I., N.Y.

• **Lockheed Aircraft Corporation . . .** The first Lockheed airplane to make an extended flight on turboprop power is the company's original Constellation, tagged as "Old 1961" by her crew. During this current series of test flights, Lockheed's flying laboratory carries an Allison YT-56 in No. 1 engine position, with one Wright turbo-compound of 3,250 hp. and two Pratt & Whitney R-2800-C's of 2,700 hp. each in the other three positions. (The rating of the YT-56 approximates 3,750 eshp.) The Allison YT-56 is to be installed in Lockheed's first turboprop-powered C-130, the USAF's four-engine personnel-cargo transport. By flying a C-130 engine on the laboratory plane, Lockheed can keep its power-plant experience ahead of that obtained in regular C-130 flying, which should be started any time now. For the purposes of these tests, "Old 1961" has received a new paint job, a Super Constellation-type tail, and a new aluminum outer skin.

• **Marquardt Aircraft Company . . .** A new multipurpose variable-area exhaust nozzle is now being developed at Marquardt and will soon be ready for testing. It is said that this new nozzle will provide up to 35 per cent reverse thrust and positive control of forward thrust independent of engine r.p.m. This nozzle can reportedly be used to trim area to meet the requirements for maximum engine thrust on take off, regardless of ground temperatures, and to meet the requirements for water-alcohol injection boost. Another feature listed for this nozzle is its ability to trim in flight to an area that will

The first production model of the P5M-2 Marlin took place on April 29. Built by The Glenn L. Martin Company for the U.S. Navy's antisubmarine warfare service, this seaplane is equipped with the latest electronic devices designed to search out enemy submarines and is armed with depth charges and rockets. The P5M-2, which has a high "T" tail as one of its distinguishing features, is powered with Wright Cyclone turbocompound R-3350-32W engines, built by Curtiss-Wright Corporation's Wright Aeronautical Division.

RESEARCH KEEPS **B.F.Goodrich** FIRST IN RUBBER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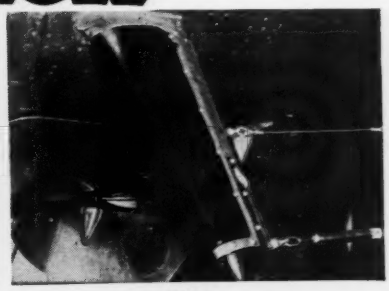
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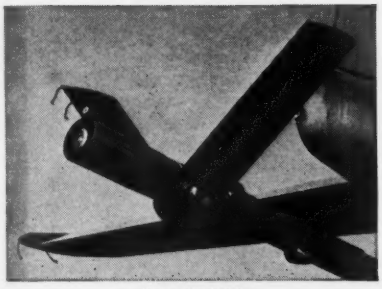
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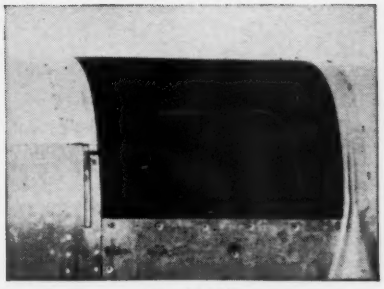
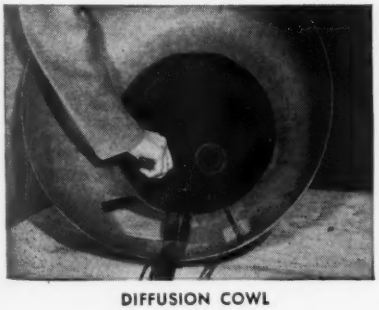
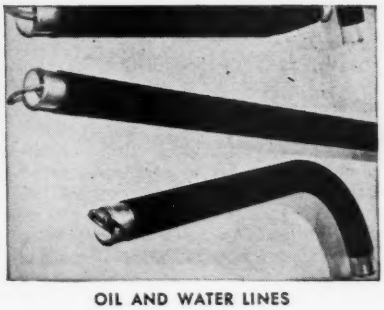
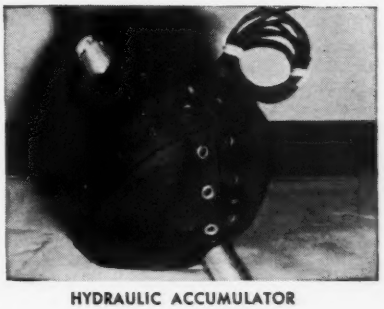

AIR SCOOP

ENGINE INTAKE


DIFFUSION COWL


OIL AND WATER LINES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B. F. Goodrich electrically heated rubber can be made as thin as .040" for protected locations, and .060" for external use. It simplifies design, saves weight, can be cemented right onto the part. It's another exclusive development of B. F. Goodrich engineering and research for aviation. Other B. F. Goodrich aviation products: tires, wheels, brakes; De-Icers; Avtrim; inflatable seals; fuel cells; Rivnuts; accessories. Write: *The B. F. Goodrich Co., Aeronautical Sales, Akron, Ohio.*

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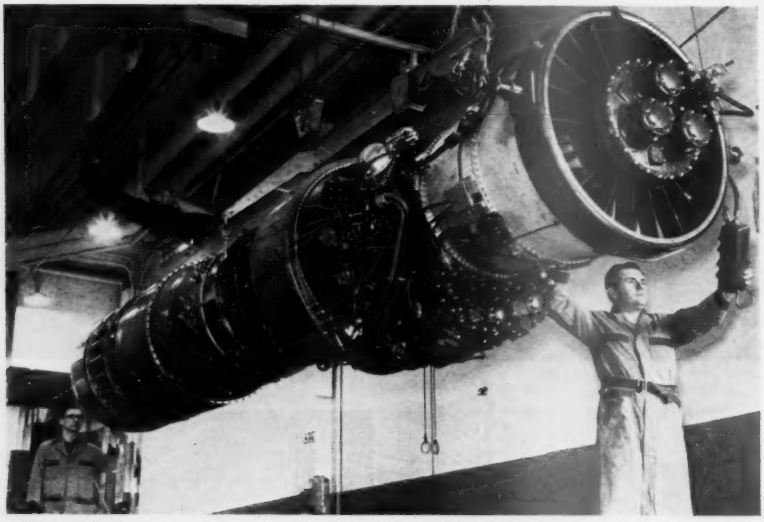

One of the first views to be released of the J-57 turbojet engine is shown here. This engine, designed and built by Pratt & Whitney Aircraft Division of United Aircraft Corporation, is equipped with an afterburner. (The front end of the engine is to the right; the afterburner section is toward the left rear.) Among the aircraft powered with the afterburner-equipped J-57 are: North American's F-100 Super Sabre; Convair's F-102; and Douglas' F4D Skyray.

achieve the minimum specific fuel consumption from the turbojet engine for a given cruise-thrust requirement. The initial applications of this nozzle will be for nonafterburning turbojet engines.

• **The Glenn L. Martin Company . . .** The Navy Viking No. 10, a single-stage high-altitude rocket weighing 7½ tons and measuring 42 ft. in length, was launched successfully on May 7 at the White Sands Proving Ground, N.M. At that time, it equaled the altitude record of 136 miles set previously by Vikings 7 and 9. Like its forerunners, Viking No. 10 was designed and built by the Martin company for the Naval Research Laboratory to be used in high-altitude research in cosmic rays, atmospheric composition, radio propagation, photography, and spectroscopy. This Viking, like its predecessors, was powered by a 20,000-lb.-thrust rocket engine made by Reaction Motors, Inc. At the point during the rocket vehicle's ascent when its fuel supply of liquid oxygen and ethyl alcohol was exhausted, it was traveling at a speed of 4,000 m.p.h. During the Viking's flight into the upper atmosphere, the NRL-designed telemetering equipment transmitted data on performance and atmospheric conditions back to the ground stations where it was recorded. In order to effect the physical recovery of some instruments carried by the Viking—for example, cameras—a provision was included in the vehicle whereby the nose section was blown off by explosives during the rocket's descent. . . . The Martin Aircraft Scholarship Fund for Cooperative Students has been established at the Georgia Institute of Technology. This is in the form of an endowment amounting to $16,000 which will make possible one or more annual scholarship grants of $307 each to cover the full tuition for the first academic year of cooperative students from Maryland and the District of Columbia. Under Georgia Tech's cooperative plan of engineering education established in 1912, students alternate every quarter between resident study at the school and a work period at Martin or at one of the other participating firms. After completing eight alternating quarters of resident study in 4 years, students finish their last four quarters by staying at the school for the entire fifth year. It is said that more than 90 per cent of cooperative students entering Georgia Tech eventually graduate. The first award under The Martin Aircraft Scholarship Fund will be made to a freshman cooperative student entering in the 1954–1955 academic year. Preferential selection will be given to residents of Maryland and the District of Columbia, with special consideration being accorded to sons of employees of the Martin company, if they are fully eligible for admission. Final selection will be made by the Award Committee consisting of the President of Georgia Tech and the President of Martin (George M. Bunker).

• **Minneapolis-Honeywell Regulator Company . . .** The Aeronautical Division has issued a new booklet that describes in detail the company's advanced stabilization system designed especially for transonic and supersonic aircraft. Components of the system covered in the booklet include rate gyro, actuator, air-speed compensator, surface-position potentiometer, amplifier-calibrator, altitude compensator, and pedal-force transducer.

• **Northrop Aircraft, Inc. . . .** An incremental motor, developed by Northrop's electro-mechanical laboratory for digital servo-mechanism applications, is being built under license by Stepper Motors Corporation. It is designed to operate at speeds up to 30 pulses per sec. It converts electrical pulses into mechanical movement, giving positive control.

• **Pesco Products Division, Borg-Warner Corporation . . .** The appointment of Robert G. Allen as President and General Manager of Pesco Products was announced on May 4. Mr. Allen, who was formerly Vice-President of Great Lakes Carbon Corporation, served two terms in the U.S. House of Representatives (1937–1940). It was also announced that Robert J. Minshall, FIAS, former Pesco President and General Manager, was named Chairman of the Supervisory Board and the Division's Director of Research and Development.

• **Pratt & Whitney Aircraft Division, United Aircraft Corporation . . .** A 3-year lease has been signed by the company for a 97,000-sq.ft. building now under construction in South Windsor, Conn., and scheduled for completion by October 1. The building is being constructed to Pratt & Whitney's specifications and will be an expansion of the company's present facilities for work on development of an atomic energy aircraft engine. The building and the 12 acres of grounds on which it is located are the property of Utilities Industries Company. The leasing arrangements have been approved by the U.S. Air Force and the Atomic Energy Commission.

• **Ryan Aeronautical Company . . .** A recent Department of Defense announcement revealed that complete rocket motors for the Corporal, a U.S. Army Ordnance surface-to-surface missile, are being manufactured by Ryan. The rocket motor for the Corporal was designed by the Jet Propulsion Laboratory of the California Institute of Technology. The missile itself is a product of Firestone Tire & Rubber Company.

• **Shell Oil Company . . .** It was recently announced by the Shell Fellowship Committee on behalf of Shell Chemical Corporation, Shell Development Company, Shell Oil Company, and Shell Pipe Line Corporation that the expenditures for fundamental research and fellowship programs have been increased from $177,500 in 1953–1954 to $263,500 in 1954–1955. Grants for fundamental research are made to university departments to aid them in expanding research in their particular fields. A new feature incorporated in the research grants for 1954–1955 is the supplementing of each $5,000 grant designated for a specific science department by an unrestricted grant of $2,500 to be used by the schools as they see fit. The number of research grants are being increased from 14 to 19. The fellowship program is designed to assist outstanding graduate students in obtaining advanced degrees. There will be 49 fellowships, an increase of one over the 1953–1954 program. Schools receiving research grants are: California Institute of Technology, Cornell University, University of Chicago, Harvard University, Massachusetts Institute of Technology, Northwestern University, University of Notre Dame, Princeton University, Rice Institute, University of Rochester, St. Louis University, Stanford University, and Yale University. The research grants are in the fields of chemistry, chemical engineering, geology, geophysical engineering, mechanical engineering, metallurgy-corrosion, physics, and engineering mechanics. The fellowships will aid students working in chemistry, chemical engineering, geology, geophysics, mechanical engineering, petroleum production engineering, physics, plant science, and business administration. Fellows are

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selected by their respective schools, each fellow receiving $1,500 for his personal use with tuition and fees being paid. The schools receive an additional amount to cover fellows' research expenses. Candidates in their final year of doctorate study are given preference, but awards may be made by a school to other graduate students. The fellows are under no obligation to Shell.

• **The H. I. Thompson Fiber Glass Company . . .** The company's new plastics division was formed from the recently purchased Industrial Plastics Company. Industrial Plastics Company continues to operate under that trade style as a division of Thompson and manufactures a variety of products for industry and consumer use in the field of glass-reinforced plastics. Heading this new plastics division is Brandt Goldsworthy, who has been elected a Vice-President of Thompson.

• **Thompson Products, Inc. . . .** A wave-guide switch, 0.75- by 1.5-in. guide size, is now available to the microwave field. This new switch has the following features: VSWR—1.05 to 1 maximum; crosstalk—50-db. minimum; actuator—110-volt, 60-cycle; actuation time—0.5-sec. maximum; VSWR during switching—1.2 to 1; and power handling ability—approximately 0.35 megawatt cw. Additional information may be obtained through the Electronics Division of the company.

• **Vickers, Inc. . . .** Brochure No. 5205 describes the standard aircraft-type hydraulic motors put out by Vickers. These motors are built in 24 sizes and range in capacity from 0.422 gal. per min. (at 1,500 r.p.m.) to 23.8 gals. per min. (at 1,500 r.p.m.). The smallest size may be operated at speeds up to 9,100 r.p.m. The larger sizes must be operated at slower speeds. The company states that hydraulic motors of a specific size and incorporating special features can be built to suit the design engineers' requirements.

• **Westinghouse Electric Corporation . . .** Two identical 600-r.p.m. synchronous motors that are to power the modified Southern California Cooperative Wind Tunnel are being tested. (The existing 12,000-hp. subsonic tunnel is being converted to a variable-pressure transonic tunnel and will operate at speeds from Mach Number 0.7 to 1.3 at pressures ranging from 0.1 to 4 atmospheres.) The motors will be mounted in tandem; they will, however, have no physical connection. Each motor will have two fans, one mounted at either end of the rotor shaft. Each motor will be supported by 12 aerodynamically-shaped struts that also act as stationary blades for the fans. These struts will carry cooling air, electric cables, and lubricating oil into the motors. The motors will be started by utilizing the wound-rotor drive elements taken from the existing subsonic tunnel as an induction-frequency converter. The tunnel conversion is scheduled for completion in early 1955. . . . A 600-kw., 400-cycle generator for servicing aircraft on board ship has been built by Westinghouse. It is a four-pole machine that has a rated speed of 12,000 r.p.m. and weighs 2,100 lbs. The rotor has a diameter of 9.5 in. This generator was first used on the U.S.S.

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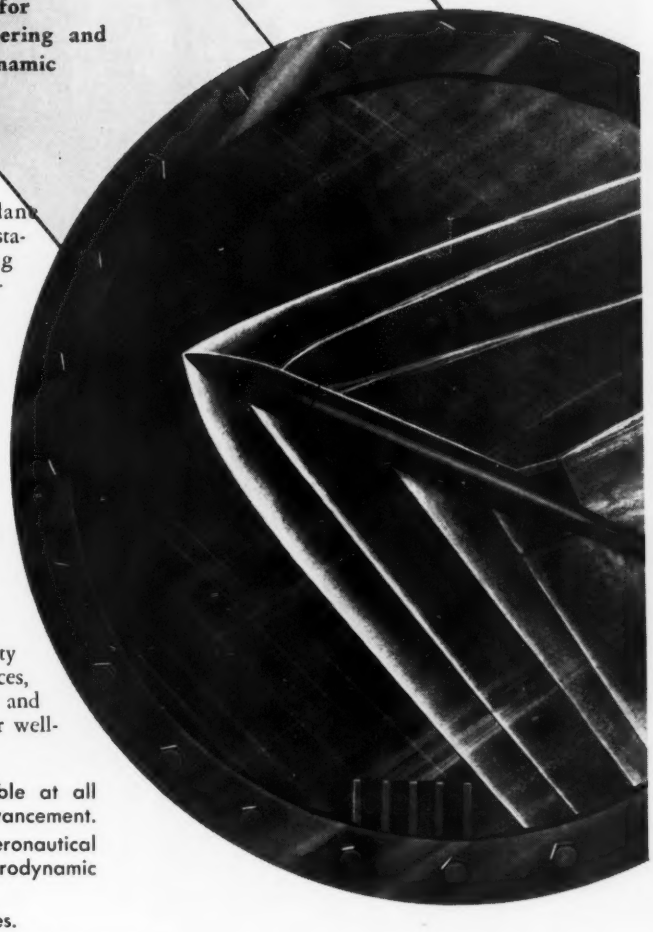

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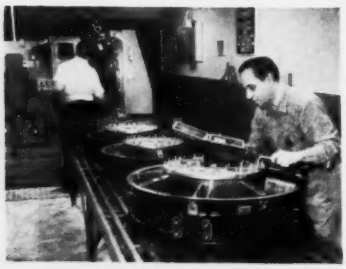
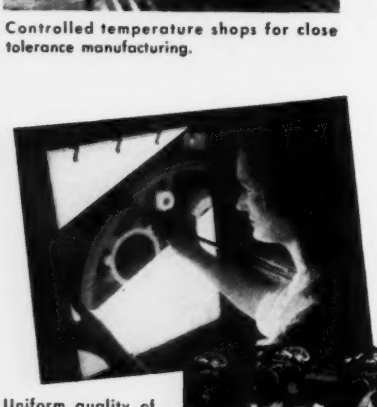
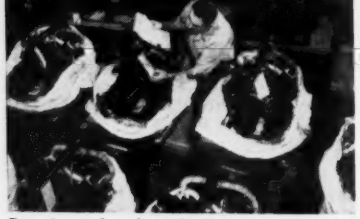


Controlled temperature shops for close tolerance manufacturing.

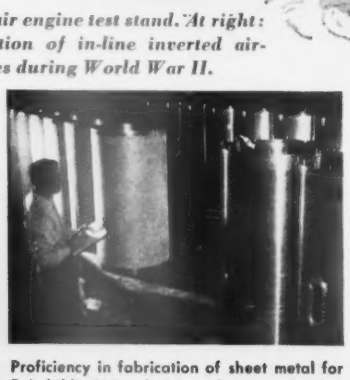
1925: Open-air engine test stand. At right: Mass production of in-line inverted air-cooled engines during World War II.



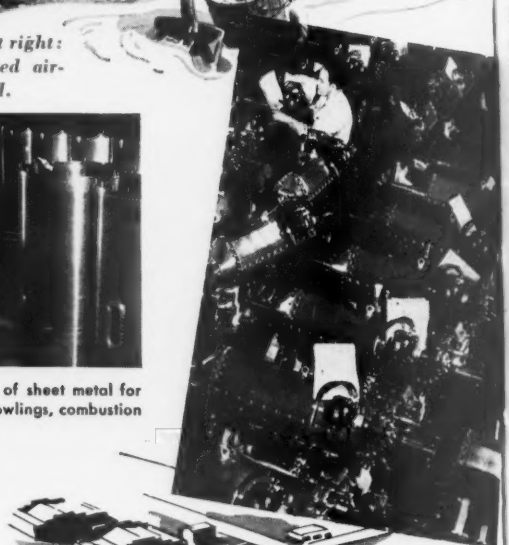
Uniform quality of material insured by modern inspection equipment and techniques.

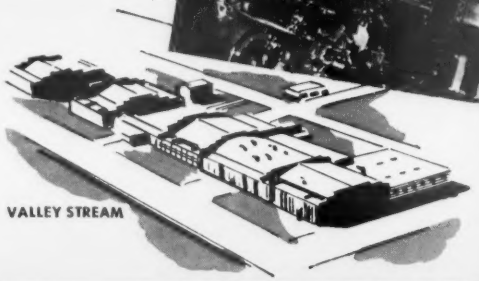


Experimental and production test cells to accommodate quantity output of auxiliary power generators—Fairchild turbojet engines.



Proficiency in fabrication of sheet metal for Fairchild's J44 turbojet cowlings, combustion chambers and nozzles.





VALLEY STREAM

Over a quarter century has passed since a single engine test stand served Fairchild Engine Division as it ventured into aviation engine and auxiliary powerplant design. Today, three up-to-the-minute facilities provide nearly a million square feet of floor space. This is progress in production! But, even more important, is the Fairchild creative engineering that has resulted in this logical expansion.

SOME OF THE SIGNIFICANT MILESTONES ARE:

Designing and testing of the first Caminez radial aircooled engine.

Development of the most successful inverted, in-line aircooled engine, produced in thousands for World War II military training and liaison planes.

Mass production of highly reliable, economical auxiliary generators for bombers and transports.

Volume production of turbine wheels, front and rear frame assemblies for the highly successful, reliable combat-proven GE J47 turbojets.

Applied design experience, production know-how to develop, and produce in quantity a bantamweight 1,000-lb. thrust turbojet for U. S. Armed Forces target drones.

From these accomplishments and years of experience in engineering design—and in mass production of aircraft engines and powerplants—came the know-how for the development of today's jet engines, auxiliary powerplants, custom made precision built equipment for highly specialized functions and new types of underwater ordnance. Other projects, still "classified", are adding more and more power and strength to our National Defense effort.

Complete research laboratory provides facilities for testing new theories, new fuels—new metals.

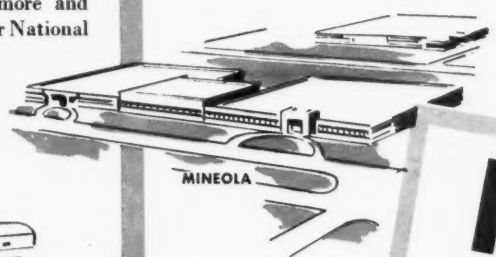
Miniature models of Fairchild's production equipment permit efficient planning for economical production.

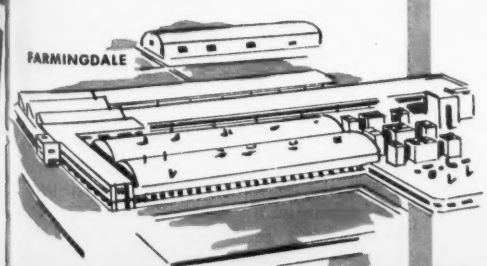
TEAMWORK IN RESEARCH·DESIGN AND MANUFACTURING

Sound, creative engineering at Fairchild springs from experience. Confidence inspires teamwork and stability—provides the urge to experiment into new areas, to test new theories, new metals and new fuels. From the drafting boards come new designs for advanced powerplants and underwater ordnance. In the manufacturing plant itself, experienced production specialists impatiently seek better ways of producing higher quality products at minimum cost. Past performances and present assignments hint of even greater dependence upon Fairchild for the vital components of tomorrow's more complex weapons systems.

New methods, such as Fairchild's Al-Fin development, provide new design opportunities.

Pride of workmanship by experienced craftsmen allows no compromise with quality.





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"Timmerman." . . . Three Vice-Presidents and a new Secretary of the corporation were recently elected. The Vice-Presidents are: Walter J. Maytham, Dale McFeatters, and Otis O. Rae. E. V. Higgins, Vice-President—Corporate Affairs, was also named Secretary. Mr. Higgins succeeds C. W. Pomeroy, who retired.

Meet Your Section Chairman

John H. Meyer

St. Louis Section

John Meyer entered the aeronautical field after several varied experiences in other fields of engineering. A native of Columbia, Mo., he attended schools there and was graduated from the University of Missouri with a Bachelor of Science degree in Civil Engineering in 1938. Mr. Meyer's first entry into the engineering field came soon after graduation, when he worked as a Rodman for the Milwaukee Railroad. This was followed by a job with the U.S. Geological Survey as a Junior Hydraulic Engineer "keeping track of the amount of water running down the Missouri River," as he says.

An interest in a career in aeronautics led Mr. Meyer to the Consolidated Aircraft Corporation in San Diego, where he was employed as a Loftsman, Tool Checker, and Junior Stress Analyst from 1940 to 1942, working on the "Catalina," the "Coronado," and the B-32. During this same time, he also completed war-training courses at the University of California in airplane structures, aerodynamics, and related subjects.

Returning to his home state of Missouri in July, 1942, Mr. Meyer accepted a job as Assistant Stress Analyst at McDonnell Aircraft Corporation in St. Louis. He advanced rapidly to Group Leader and in March, 1945, became Project Stress Engineer on the XF2D, now more widely known as the McDonnell "Banshee."

In July, 1946, he was appointed Chief of Structures, the position he holds today. Mr. Meyer has worked on varied McDonnell projects, among them being the XP-85 "Parasite Fighter" and the B-29 program at Memphis.

In addition to his work at McDonnell, Mr. Meyer has been a member of the NACA Structures Sub-committee for 5 years.

Previous to his election as Section Chairman, Mr. Meyer held the post of Program Committee Chairman, in which capacity he provided the Section membership with a most interesting and diversified program during the 1952–1953 term.

Mr. Meyer's ardent interest in all phases of aviation is well known to all his friends and associates. In order to supplement his knowledge of aerodynamics and hydrodynamics, Mr. Meyer had at one time started an expedition down the Missouri River in order to study river currents and dynamic stability of watercraft.

He and his wife, Betty, are the parents of three children: John H., Jr., 14; William, 12; and Maria, 5. They reside in Overland, Mo., where he is active in community projects, and also serves as a Boy Scout troop committeeman.

ALLEN H. MADRICK
Chairman, Publicity Committee
St. Louis Section

IAS Sections

Baltimore Section

Richard W. Sanford, *Secretary*

The forty-ninth meeting of the Baltimore Section of the Institute of the Aeronautical Sciences was held in Maryland Hall at The Johns Hopkins University on Tuesday, April 6, at 8:45 p.m. The meeting was attended by approximately 25 members and guests.

The meeting was devoted to the presentation of a talk entitled "The Upper Atmosphere: Where the Meteorologist Stands Today" and delivered by Brig. Gen. Thomas S. Moorman, Jr., Deputy Commander, USAF Air Weather Service. General Moorman's talk was supplemented with additional presentations by Lt. Col. Arthur F. Gustafson and Dr. K. R. Johannessen, members of the USAF Air Weather Service staff.

General Moorman described the objectives of the USAF Air Weather Service and some of the problems and phenomena encountered in performance of its work. The basic objective of the Air Weather Service is to place all possible information on global weather conditions in the hands of Air Force operational personnel, so as to enable them to predict weather factors that will be encountered during performance of each missile. One of the most obvious of these factors is the direction and magnitude of winds to be encountered. Other factors, such as visibility, temperature, pressure, icing conditions, turbulence, and existence of vapor-trail condensation conditions, also are important.

In defining the upper atmosphere, General Moorman considered levels at which jet aircraft operate, that is, altitudes between 35,000 and 50,000 ft. Information on weather conditions within this altitude range is fairly complete. As airplane performance increases, it will be necessary to extend weather-gathering techniques to altitudes between 50,000 and 100,000 ft. This process of extension is under way, but, generally speaking, accuracies within this region are poor at this time.

It was emphasized that weather-data gathering is a global problem. The USAF Air Weather Service has personnel stationed in 26 countries and on ocean vessels. In addition to radiosonde techniques, B-29 airplanes are used for data gathering at medium altitudes. It is becoming increasingly necessary to establish an upper-air weather reconnaissance.

High-level winds having velocities of 200 to 250 knots are becoming increasingly important. Cloud conditions also bear a great deal of investigation. It has been thought that no clouds existed above 30,000 to 40,000 ft. It is now believed that heavy clouds may extend to much higher altitudes. Solid clouds extending from 50,000 to 200,000 ft. and above have been reported over Korea.

Icing, which is a serious problem at low levels, is not so serious at high altitudes. However, icing altitude and temperature limits have not been established with any certainty. Supercooled water droplets recently caused $\frac{1}{4}$ in. of rime ice to form on a B-47 flying at 36,000 ft. at a temperature of $-51°C$.

Turbulent air is of extreme importance to jet pilots, since its existence may decrease operating range. It has been found that, generally speaking, mountain ranges introduce turbulent conditions up to altitudes three times their height.

Effort is continually being devoted to refinement and extension of standard atmospheric conditions. As an example of variations that exist within

relatively short global distances, standard temperature at 33,000 ft. is −50°C.; however, temperatures have been found to run around −70°C. over Canada and −22°C. over Florida. Thus, standard conditions cannot be used with any certainty.

Colonel Gustafson discussed jet-stream wind conditions existing in the upper atmosphere. At mid-latitudes, upper winds are predominantly eastward. It is estimated that their average speed is approximately 130 knots. They are weaker in summer than in the winter months, and their velocity has been found to be dependent upon temperature gradients that exist at low levels. Maximum velocities are usually obtained at approximately 40,000 ft. with reductions above this altitude due to a reversal of temperature gradients.

Weather maps of the troposphere were shown illustrating changing conditions from winter to summer, and further illustrations were presented depicting progress of a jet stream in geographic position and time.

It was noted that the jet streams generally do not run directly from east to west, but that they progress in an easterly direction with the passage of time. To take full advantage of these jet streams, their progress must be plotted on an hourly basis.

Dr. Johannessen discussed meteorological turbulence and vapor trails. It was pointed out that present-day bombing is made difficult by turbulent conditions. Light-to-moderate turbulence is encountered in regions between 20,000 and 60,000 ft. as often as it is at lower altitudes. Thunderclouds are rare at high altitudes, but tops of cumulus and cirrus clouds are almost always turbulent. Turbulent areas usually exhibit patchy characteristics, variable in time over areas 50 to 100 miles in length and width, and varying from 100 ft. to 1,000 ft. in height.

High-level turbulence is primarily caused by the existence of a critical magnitude of wind shear. Vertical wind shear is of higher magnitude and is more important than horizontal shear. It was noted that shears are extremely high in jet streams, so that there is a remarkable association between turbulence and jet-stream conditions.

A military hazard of particular interest is the existence of condensation trails. These trails are usually above 25,000 to 30,000 ft. at low temperatures over our latitudes. Normally, vapor trails are due to engine water-vapor output. They vividly mark the position of aircraft that might be unnoticed except for the presence of these trails. Vapor trails also are sometimes caused by adiabatic cooling that takes place at the wing tips. Wing-tip trails usually do not increase visibility seriously. It is possible to predict whether or not a

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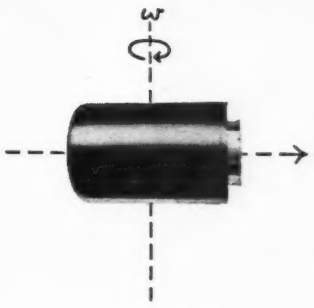

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Type	Max. Output Null Ratio	Ratio Max. to Min. Input Rate	Dimensions	Weight
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HIGH SENSITIVITY	1000:1	2000:1	2 5/16" x 4 1/4"	4 1/2 lbs.
MINIATURE	1000:1	1500:1	2" x 3 5/16"	1 lb.

FLOATED RATE INTEGRATING GYROS

Type	Damping Ratio	Dimension	Weight	Drift Standard Deviation
HIGH ACCURACY	.3	6" x 3 3/4"	6.4 lbs.	.1°/hr.
MINIATURE	1	2" x 3 21/32"	1 3/8 lbs.	1/3 millirad/sec.

GYRO ACTIVATED RATE SWITCHES

Type	Cutout Rate	Dimensions	Weight
STANDARD	25°/sec.	3 1/2" x 5 3/32"	3 3/4 lbs.
MINIATURE	25°/sec.	3 1/2" x 4 3/16"	2 3/4 lbs.
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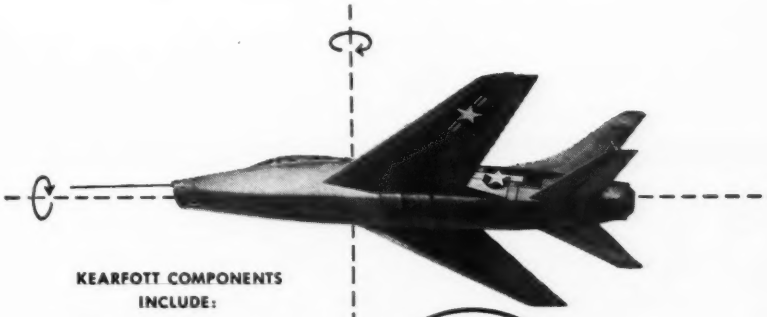

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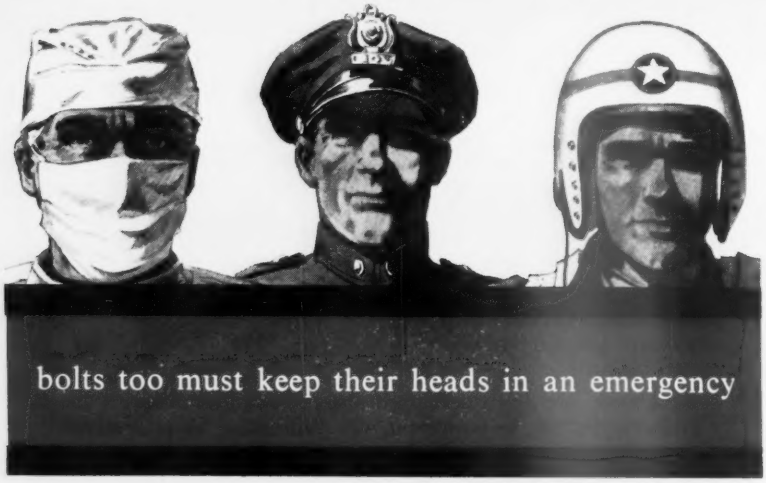

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trail will be created by observations of temperature, pressure, and humidity conditions. These observations are part of the essential service performed by the USAF Air Weather Service by means of meteorological data sampling.

Chicago Section

Leland W. Sims, *Secretary*

On April 21, the Chicago Section met in the Museum of Science and Industry. At 6:30 p.m., 32 people had dinner in the Museum Cafeteria, and 44 members and guests met in the auditorium.

The meeting was opened at 7:30 p.m. by the Section Chairman, Alfred F. Stott. Mr. Stott then introduced Charles L. Bonnette, Vice-Chairman of the Section, who presided for the evening. Mr. Stott pointed out that this was Mr. Bonnette's last meeting of the year in Chicago, as he was leaving shortly for Texas where he will be associated with Chance Vought Aircraft, Inc. Chairman Stott expressed his regrets at Mr. Bonnette's departure and extended his good wishes for the future.

Mr. Bonnette then introduced Irving Pinkel, Associate Chief of the Physics Division, NACA, who delivered an illustrated lecture on crash-fire research. Mr. Pinkel described the objectives of the tests, which were conducted by the NACA, and the full-scale airplane crash-fire procedures and equipment used. Mr. Pinkel illustrated his talk with spectacular colored motion pictures and slides. The series of pictures showed the manner in which aircraft caught fire and the propagation of the fire on and around the aircraft during the initial few minutes after a crash. Different types of obsolete aircraft were used in the series of tests, and a variation of terrain was also accomplished in order to determine its relation with the start of crash fires. Mr. Pinkel led a discussion period at the conclusion of the talk and was generous in answering many questions from a small, but extremely interested, audience.

Mr. Bonnette thanked Mr. Pinkel for a fine evening. He expressed his own regrets in leaving his many friends in the Chicago area and thanked the members of the Program Committee for their support during the year. Mr. Bonnette closed the meeting at 10:30 p.m.

Los Angeles Section

Evert C. Hokanson, *Secretary*

Lt. Col. John P. Stapp, USAF(MC), Chief, Aero-Medical Field Laboratory at Holloman Air Development Center, addressed the Los Angeles Section on April 15 on the subject, "Living Through 100 G's." This intriguing title truly represents Colonel Stapp's outstanding accomplishments. Many phases pre-

sented were of vital interest to aircraft designers. Among them were: (1) a brief history of aviation medicine; (2) studies of man under stress, i.e., sudden changes in environment; (3) the crash problem and human crash tolerance; (4) design of seats, seat belts, leg straps, and shoulder harness to minimize crash injuries; and (5) high-performance decelerators for investigating linear forces, tumbling, and wind blasts in high-speed escape from aircraft.

The work of Colonel Stapp has resulted in establishing that human limits to crash-type forces are considerably in excess of aircraft strength specifications. He has proved that man can survive impacts of 100 g's, if properly protected. While much of the test work has been done by volunteers, Colonel Stapp has never requested any volunteer to participate in a test that he himself has not first experienced.

Dr. John R. Poppen, Consultant in Aviation Medicine, when commenting on the address, stated the primary message of Colonel Stapp was that he has proved that the human body can take a tremendous amount of stress, more than was hitherto believed possible.

A. M. Mayo, Chief of the Equipment and Interior Section at Douglas Aircraft Company, stated that Colonel Stapp has greatly assisted aircraft designers by showing that many encumbering safety devices formerly believed necessary are not required. However, proper design is of paramount importance.

Colonel Stapp was introduced by Walter E. Hinds, of the Program Committee. R. Richard Heppe presided at the meeting, attended by over 250 members and their guests.

▶ "Miniaturization of Electronic Circuits and Components as Used in Aircraft" was discussed by Dr. S. G. Lutz, Head of Miniaturization and Communication Department, Advanced Electronic Laboratory, Hughes Aircraft Company, at the April 7 Specialist Meeting. In addition to indicating trends in miniaturization of air-borne electronic equipment, he stressed the need for improved wiring and packaging techniques. The system aspects and economics of miniaturization were examined. Numerous design examples were shown.

▶ "Design Producibility Establishes Lower Costs" was the title of the address that Elliott A. Green, Group Engineer, Production Design, Lockheed Aircraft Corporation, gave at the April 29 Specialist Meeting. Mr. Green discussed the aspects to be considered for maximum producibility in their relation to costs. He stated that engineers in Aerodynamics, Preliminary Design, and Detail Design must work as a team to determine the design producibility as well as the function of an air frame.

▶ The "Spring Fling" was a huge success. This Los Angeles Annual "Spring Test Hop" was thoroughly enjoyed by over 100 couples on May 1 at the IAS Building. The Dance Committee is to be congratulated for the beautiful decorations and the selection of Ben Brown's Orchestra.

New York Section

T. F. Hammen, Jr.

Secretary-Treasurer

The April 22 dinner meeting of the New York Section was held at Fairchild Engine Division, Fairchild Engine and Airplane Corporation, Farmingdale, L.I., N.Y. An enjoyable social hour and dinner preceded the informative technical meeting that was attended by approximately 200 members and guests. Professor F. K. Teichmann acted as Chairman.

The principal speaker of the evening was J. C. Shroads, Manager of Field and Installation Engineering, Fairchild Engine Division, who spoke on "A Small Turbojet and Its Applications to Pilotless Aircraft." W. T. Immenschuh, Executive Engineer, Ryan Aeronautical Company, presented a discussion of target drones, including the propulsion aspects. Summaries of their presentations are covered in the succeeding paragraphs.

Mr. Shroads discussed the evolution of the small Fairchild J44 turbojet engine which had been originally designed for Navy missile application and was later applied to the "Firebee" target drone. The initial engine-design philosophy was discussed as were the problems encountered when this engine, designed for medium-speed low-altitude operation, was applied to the Firebee with its high-altitude high-speed requirements. Elaboration of the solution of these problems involving altitude operation, lubrication, and engine-speed control was presented.

In conclusion, Mr. Shroads expressed Fairchild's appreciation for the cooperation received from the Navy Bureau of Aeronautics, under whose cognizance the work was accomplished, and for that received from the USAF and Ryan Aeronautical Company during the flight test phases.

A highly interesting color movie was shown depicting the operations of the Ryan Firebee target drone during its development program. This was the first presentation of this film to an open meeting.

Following the showing of the movie, a rather complete discussion on the design and operation of the Firebee target drone was presented by Mr. Immenschuh. This target drone, partially declassified only recently, simulates present-day first-line fighters in speed and altitude operations. Mr. Immenschuh concluded by discussing the operational problems connected with target control, parachute recovery systems, and general target recovery in remote and ocean areas.

The J44 engine and a cutaway model together with a Ryan Firebee target drone were exhibited and referred to during the talk and the discussion.

Philadelphia Section

Emily Rogers Gibbs, *Secretary*

The final meeting of the season was held on May 5 at the Engineers' Club, with Grahame Aldrich, Director of Special Projects in the Research Division of the Air Transport Association of America and an authority on passenger traffic motivation, volume, character, and flow, as speaker.

Mr. Aldrich gave a fine and informative talk on "The Impact of Integrated Rotary-Wing Flight Schedules upon the Service Pattern at Fixed-Wing Airports" as follows:

"Since the advent of Korea public interest in the transport helicopter has become increasingly evident. Expressions of this interest are to be found at the Civil Aeronautics Board, where 52 open dockets attest the willingness of various applicants to conduct common-carrier air-borne operations in the public interest. For the past 18 months the Air Transport Association, through its Rotorcraft Committee, has spared no effort to determine the place of the multiengined helicopter in carrier operations. Manufacturers, in turn, have produced and flown two multiengine-type aircraft. These are the Piasecki H-16 and the Sikorsky S-56, Marine Assault Transport. More recently the RTCA has established Special Committee 63 to devise air-navigational aids which will assure high-frequency landings and take-offs within congested terminal areas without sacrifice of safety. The Aircraft Industries Association, through its Helicopter Council, has been most active in the field of heliport design. And finally, the Airport Operators Council in session at Tampa, Fla., April 13, devoted close attention to the impact of rotary-wing operations upon the landing-fee revenues at existing fixed-wing airports. There seems no reason to doubt that helicopters are, indeed, coming!

"Airport management currently represents millions of dollars in long-term capital investments. This fact, coupled with the admitted ability of multiengined transport helicopters to replace the DC-3 and modern twin-engined aircraft in scheduled air-line service, presents a serious problem for airport operators. Clearly, the root of this prob-

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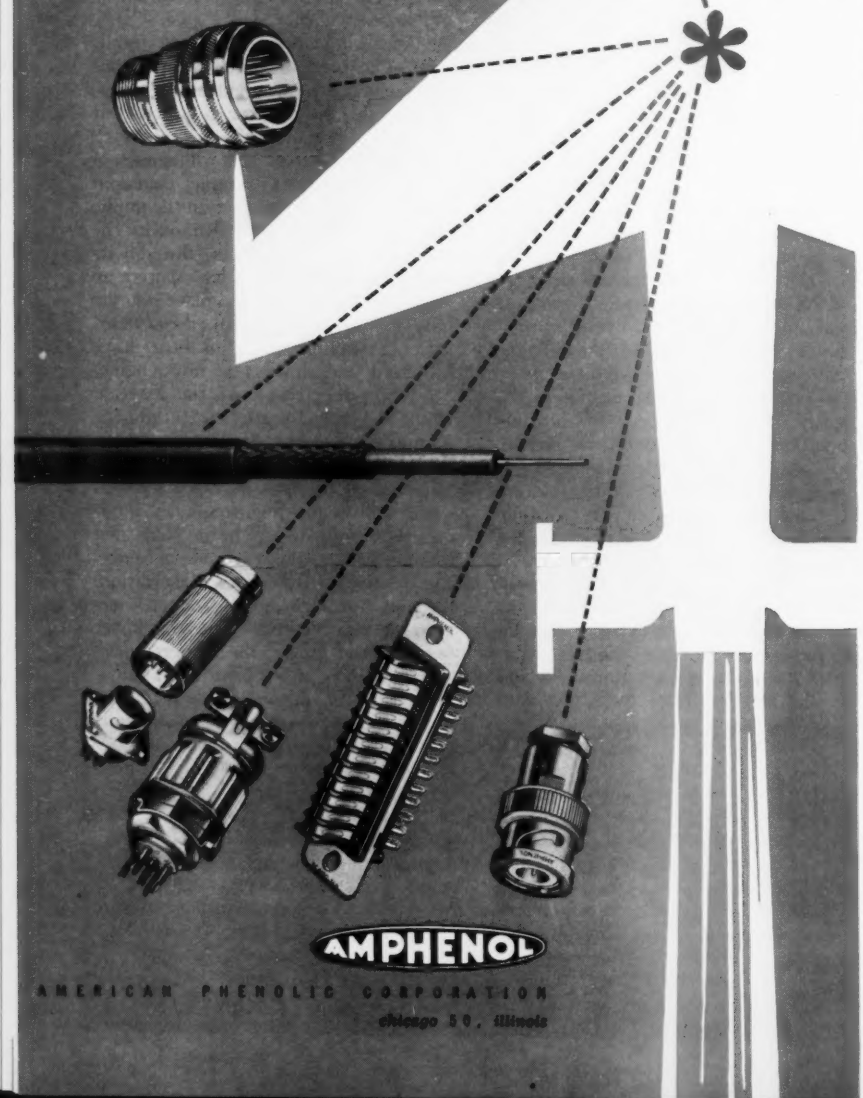

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lem concerns the degree of fixed-wing operations which may be subject to future diversion by rotary-wing aircraft. A corollary problem concerns the amount of time which yet remains before the introduction of helicopters into scheduled services.

"As of the present date, 551 airports are utilized by the nation's scheduled air lines. If mature rotary-wing services had been operated in 1953, the number of scheduled landings at fixed-wing airports would have been reduced by approximately 37 per cent. In turn, airport landing-fee revenues would have been reduced by 30 per cent.

"As a general rule, the helicopter will least affect the larger airports. For example, at the 24 highest ranked airports, measured in terms of scheduled flight departures, which exceed 20,000 per year, the 1953 helicopter diversion would have amounted to 35.9 per cent of flight departures resulting in a 26.35 per cent loss of landing-fee revenues. However, at the 315 airports having less than 2,000 scheduled flight departures per year, the situation is different. In this case 60 per cent of fixed-wing operations would have been diverted by the helicopter, together with 60.4 per cent of related landing-fee revenues.

"Appraisal of the 'time remaining' until multiengined helicopters are fully integrated with existing fixed-wing airline schedules, appears to range between 6 and 10 years. This means that airport operators should lose no time in the re-evaluation of airport expansion plans now scheduled for the decade 1955–1965.

"These plans should concentrate upon (a) the development of an 'airport heliport,' (b) the development of 'in town' heliports, and (c) conversion of the fixed-wing operations area to accommodate a decided increase in the number of four-engined and, in some cases, jet-transport operations.

"Although the rotary-wing diversion factors previously indicated are impressive, it must be remembered that the attainment of such diversion will consume 6 to 10 years' time. Accordingly, it is a matter of some interest to consider the airport outlook as of 1965. By that time, it is anticipated that the nation's 551 airports will handle 3,870,860 annual flight departures, in contrast to the 1953 level of 2,654,000. The 1965 airport operations will be split on the average, at 70.1 per cent fixed-wing departures, 4.9 per cent inter-city helicopter transfer operations, and 25 per cent rotary-wing airport-to-city shuttle service. It is, therefore, apparent that the integration of rotary-wing aircraft into scheduled air-line service will not result in absolute decline of fixed-wing flight departures. This particular airport activity will continue to expand, but at an annual rate of

growth which is substantially lower than previous levels of experience."

Officers and Council elected for 1954–1955 were announced. The officers are as follows: Chairman, Alfred A. Little, II, NAES; Vice-Chairman, Louis P. Clark, NADC; and Treasurer, Earle Stewart, Piasecki. (The Secretary's name was not included in the report.) The Council is composed of: Dr. Edward Seckel, Princeton University; Samuel Berkowitz, The Franklin Institute; John S. Kean, NAES; Ralph H. McClarren, Consulting Engineer; Harry Tobey, Piasecki; Dale Hamilton, Piasecki; Julian P. Perry, Eastern Rotorcraft; Capt. Grayson Merrill, NADC (Johnsville); Harold E. Lemont, Jr., Jacobs Aircraft; and James B. Jones, Kellett Aircraft.

San Diego Section

H. C. Matteson

Corresponding Secretary

The April activities of the San Diego Section consisted of one technical meeting and one dinner meeting, both held at the San Diego IAS building.

▶ "Landing Gear Preliminary Design" was the subject of a technical meeting presented on April 6. The speaker was Wilfred Nugent, Senior Design Engineer of Convair, San Diego. Mr. Nugent opened his talk with a review of the basic landing-gear dynamics involved in the landing impact. From this background, he proceeded into a discussion of the comparative merits of the air-oil and the liquid-spring types of shock struts. He noted that the small size of the liquid spring offered definite advantages in certain applications. The speaker also discussed such factors as the influence of fluid compressibility on the operation of the liquid spring, the effect of cylinder pressure and material strength on strut weight, and the effect of fluid temperature on shock-absorption qualities. Mr. Nugent's talk was a well-rounded appraisal of the more important aspects of current landing-gear design problems.

▶ The San Diego Section was fortunate to have Capt. Tom Connolly, USN, as speaker for the April 22 dinner meeting. Captain Connolly's subject for the evening was "Naval Air Weapons Testing." The speaker was eminently qualified to discuss this subject, having a distinguished record as a Naval combat pilot in World War II, and having served as Assistant Director of Flight Test and Director of Test Pilot Training at the Naval Air Test Center. Captain Connolly is currently assigned to the Inyokern Naval Ordnance Test Station. He is an Associate Fellow of the IAS.

Captain Connolly opened his talk with a description of the various Naval testing facilities located in this area. Included were the China Lake and Inyokern ranges, the NOTS Morris Dam Torpedo Range, and the San Clemente Island test ranges. The speaker then outlined the Navy administrative organization employed to obtain maximum utilization from these facilities and related weapons development centers, such as the Thompson Laboratory.

Flying qualities necessary in a fighter to assure good tracking characteristics were discussed next. Captain Connolly emphasized that rapid damping of the lateral-directional oscillation was necessary to an increasing degree with increasing combat speeds and armament ranges. Aim wander must be minimized to assure effective employment of offensive weapons, whether they be in the form of guns, free rockets, or terminal guidance missiles.

The speaker employed both movies and slides to illustrate his remarks. The talk was followed by a question-answer period. Approximately 80 members and their guests attended the meeting.

Texas Section

J. H. Boucher, *Secretary*

An aerodynamic specialists meeting was held on Wednesday, February 17, at the Arlington (Texas) State College Auditorium. The Texas Section was honored to have as its guest speaker, Dr. H. H. Kurzweg, Chief, Aeroballistic Research Department, Naval Ordnance Laboratory, White Oak, Md. His subject was "Trends in Aeroballistic Research."

Dr. Kurzweg's paper reviewed the progress of design of weapons from the days of the rock and the bow and arrow through the present-day guided missile. He compared the modern high-performance airplane with the latest types of missiles and discussed the aerodynamic problems encountered in both categories.

It is interesting to note that during Dr. Kurzweg's visit to this state, he received a certificate making him an Honorary Citizen of Texas.

▶ The regular monthly dinner meeting for February was held at 7:45 p.m. on Thursday, February 25, in the private dining room of the Fort Worth International Airport. The guest speaker was L. G. Dawson, Rol's-Royce Representative to Westinghouse Electric Corporation, who presented some new phases of jet-engine development.

Mr. Dawson discussed some of his own formulas for aircraft and engine efficiencies. He gave a basic description of our typical jet engines, as currently conceived, and made comparisons of the turbojet, turboprop, and ducted-fan types of engines.

While the subject was of a somewhat more technical nature than is usually the case at the dinner meetings, it was the consensus that Mr. Dawson covered his subject well and in a lively manner.

▶ A specialists meeting on "Aircraft Reliability" was held at 8:00 p.m. on Thursday, March 18, at the Arlington State College Auditorium. The subject was discussed by a panel headed by R. Seldon, Supervisor of Chance Vought's Reliability Group. The three panelists were: George Curtis, Chance Vought Systems Engineer, who spoke on "Components Engineering for Improved System Reliability;" Ross E. Lanier, Chance Vought Systems Engineer, who covered "Improved Aircraft Reliability Through Special Handling of Electron Tubes;" and D. Pertachok, who talked about "Experimental Determination of Guided Missile Reliability." All of these talks were supplemented by slides and were well presented. The Moderator, Mr. Seldon, made interesting and coordinating remarks.

▶ The regular general dinner meeting for the month of March was held at the Dallas Naval Air Station Officers Club at 7:00 p.m. on March 25. The guest speaker for this occasion was Robert L. Lichten, Chief Experimental Project Engineer from Bell Aircraft Corporation, who delivered a stimulating talk on "Convertiplanes and Their Promise." Mr. Lichten introduced his talk by making an analogy between the conventional convertiplane and the hammer-nail puller combination. He likened the convertiplane to the claw-type hammer which does both jobs adequately.

Mr. Lichten touched briefly upon some of the various types of convertiplanes now being developed by Convair, Lockheed, Ryan, Bell, and McDonnell. He showed slides of the VTO-type aircraft of Convair and Lockheed, pointing out that these were evolved basically as high-speed aircraft that employed high rotor-disc loading, i.e., small amounts of air greatly accelerated.

The speaker then went on to describe one of the earliest successful convertiplane attempts by Art Young, the pioneer of the Bell Helicopter Division. This design was developed over 10 years ago and featured a VTO approach with a low-disc loading and consequently a lower power-to-weight ratio. Slides were also shown of models of this craft which were successfully test flown.

Mr. Lichten thought that the high-power loadings of some VTO types would prove to be quite uneconomical for commercial usage. It was thought that JATO would probably be used on all future VTO aircraft. He also mentioned the obvious difficulties of landing VTO aircraft with a power failure. He felt that the control at take-off would probably be more marginal on the VTO, which relies on prop blast on

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the tail controls, than on the convertiplane, which utilizes cyclic pitch for control, a system similar to that of the helicopter. The discomfort factor in the 90° static attitude of the VTO types is overcome in some design approaches, such as Bell's new tilting-rotor design in which the fuselage remains effectively level and the rotors, mounted on the wing tips, rotate approximately 90° for level flight propulsion.

Mr. Lichten pointed out that helicopters have just about reached their maximum air-speed saturation point because of their inherent problems of retreating blade stall and advancing blade drag. The present helicopter speed record of approximately 146 m.p.h. is held by the Model H21C Piasecki design. Although stub wings and increased rotor velocity are additional devices for increasing the speed, the former results in a significant attitude-drag and increased horsepower-requirement problem, while the latter is hampered by the above rotor-blade problems.

Some companies, such as McDonnell with the XV-1 and Fairey with the "Rotodyne," have attempted to solve these problems through the use of unloaded rotor types (stub wing), using auxiliary propulsion for level flight. Some of the other types employ separate auxiliary power plants, while still others attempt to vary from a single power source the power to the rotor and the propeller as required. This obviously gets to be a rather complex power-plant control problem, introducing rotor dynamic problems with higher speed flight. Other types utilize a pressure jet at the rotor tips to drive the rotors, thereby trading complex transmission systems for a not-too-simple ducting. Mr. Lichten felt that the theory of a retractable rotor might provide the best solution to higher performance convertiplanes, but it too presents some challenging design problems.

Mr. Lichten concluded his excellent and descriptive talk by describing the great commercial potential of the convertiplane, which retains the vertical-take-off qualities of the helicopter and overcomes its speed limitations. Mr. Lichten was able to show his audience charts that convincingly emphasized the time-in-transit advantage of the convertiplane over all existing commercial air transportation, except jet transport aircraft.

Washington Section

T. C. Muse, *Secretary*

The Washington Section had an interesting meeting on some foreign aeronautical developments at its March 30 meeting. As usual, the technical por-

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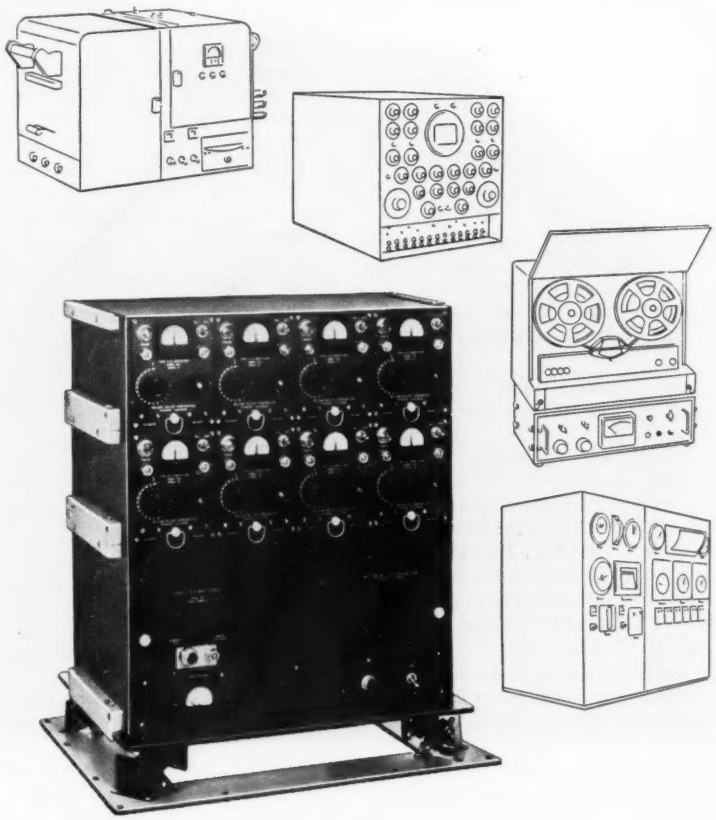

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tion of the meeting was preceded by cocktails and dinner at the Hotel Burlington.

The technical session was opened by Capt. W. C. Fortune, USN, Chairman of the Washington Section, who introduced some of the distinguished guests. These were: Dr. H. H. Kurzweg, NOL; F. A. Louden, BuAer; Carl Frederick, Consultant; Dr. Theodore Theodorsen, ARDC; J. W. Crowley, NACA; Mr. Collins, General Tire and Rubber Company; E. N. Fales, CAA; Dr. P. J. Theodorides and Dr. A. W. Sherwood, University of Maryland; and Dr. Giuseppe Garabelli, Turin, Italy.

Captain Fortune then turned the meeting over to Major Gen. J. F. Phillips, USAF (Ret.), Secretary, Guided Missiles Committee, Aircraft Industrial Association, who was the guest Chairman for the evening. General Phillips introduced the first speaker Dr. Frank Wattendorf, Director of the Secretariat, AGARD, who gave an interesting talk on the activities of AGARD (Advisory Group for Aeronautical Research and Development).

Dr. Wattendorf explained that the idea of AGARD was initially conceived in 1945 by Dr. Theodore von Kármán, who suggested such a group to the late Gen. Hoyt S. Vandenberg. In January, 1952, AGARD was set up within the framework of NATO to be advisory to the NATO Standing Group. The USAF was designated the Executive Agent, and Dr. von Kármán was appointed the first Chairman.

The Group was established on a trial basis for an initial period of 2 years and was to be composed of one or two civilian scientific representatives from each NATO country. The objective is to bring together the leading aeronautical personalities of the NATO nations with a view to recommending effective ways to utilize their research and development personnel and facilities for the common benefit of the NATO community.

The activities are generally concerned with: (1) fundamental research problems; (2) applied research problems connected with the mission of the Air Forces within NATO; and (3) coordination of the means of research within NATO.

To carry out these activities four panels have been set up. These are: (1) Aeromedical; (2) Combustion Research; (3) Flight Test; and (4) Wind Tunnel.

Some of the achievements thus far have been the issuance of monographs appropriately named "AGARDographs" and a flight-test technique manual and the use of a standard airfoil for wind-tunnel calibration and correlation. To date, the staff has been supplied principally by the United States. However, in the future it is expected that the staff will be selected from the various NATO countries.

The second speaker of the evening was Prof. J. Ackeret, Head of the Aerodynamics Institute, Swiss Federal Institute of Technology at Zurich. His lecture was an interesting presentation of work carried on at Zurich on aero-thermodynamic effects and on jet-thrust reversal.

In discussing aero-thermodynamic effects, Professor Ackeret described heating and cooling phenomena in the presence of high-frequency oscillations. The effects appear anomalous in the light of the energy relations of stationary flow, but they are understandable, if one recognizes that the general energy equation indicates a dependence upon the time rate of change of the stream function. If the flow is stationary, this term is zero; if the flow is not stationary, substantial localized heating and cooling will occur. In one set of experiments involving the use of a Hartmann ultrasonic generator, local temperatures almost 1,000°C. above the total temperature of the undisturbed flow were measured.

Professor Ackeret described laboratory experiments on a jet-braking device involving a series of annular rings located aft of the tailpipe and a number of turning vanes behind the turbine. When the turning vanes are rotated, vorticity is introduced into the stream, causing a flow, at a vane angle of about 40° to 45°, to catch in the annular rings and reverse the thrust.

An outstanding feature of this device is that by varying the tailpipe opening, the back-pressure on the turbine can be kept constant. Thus, the engine operates in a fully normal condition, regardless of the direction of thrust. There is little, if any, thrust penalty due to installation of the reversal device. The experiments included measurements at the proper Mach Numbers, but hot-stream tests had not yet been made.

In mentioning Mach Number, it is interesting that Professor Ackeret proposed the use of this term in 1929 in his first major lecture after accepting his professorial chair at the Swiss Federal Institute of Technology.

At the completion of Professor Ackeret's talk, a movie was shown demonstrating the SNECMA jet-reversal device. The movies indicated that it appreciably reduced the landing distances and in fact gave the aircraft the capability of actually backing up.

Student Branches

Cal-Aero Technical Institute

Gary N. Wagner, *Secretary-Treasurer*

The Cal-Aero Technical Institute Student Branch of the IAS, in conjunction with the SAE and AHP, held a special meeting on February 24. Our guest of honor was A. M. (Tex) Johnston, Chief of Flight Test, Boeing Airplane Company. Mr. Johnston's topic of discussion was "The Flight Testing of Jet Bombers." Mr. Johnston, the first man to take aloft the gigantic 8-jet Boeing B-52 Stratofortress, is well qualified to speak on this subject.

Mr. Johnston explained the duties of the test pilot and the importance of an engineering background. The test pilot of today has a much more complicated job than in former years. Instead of seeing only if a plane is able to fly, his job is more concerned with the testing of essential operating equipment and accessories.

Mr. Johnston's talk was augmented by colored slides and a film showing the first flight and taxi tests of the YB-52.

While security forbade too much being said about the aircraft itself, numerous design characteristics and other unclassified data proved highly interesting to Cal-Aero's future engineers.

Indiana Technical College

Harold R. Woodhouse, *Secretary*

The meeting was called to order April 13 at 8:00 p.m. by the presiding Chairman, Harold Coffman. The minutes of the previous meeting were read and approved.

The Treasurer reported $22 cash and a bank balance of $52.75, making a total of $74.75. All members who were delinquent in their dues were notified of their standing.

Terry Welty, Chairman, Activities Committee, announced that a speaker would be available at our next meeting. He also suggested that the members give lectures on subjects that they feel would interest the group as a whole. This type of program will assist the members in acquiring the ability to speak before groups effectively and without visible signs of nervousness.

North American Aviation was unable to permit our group to visit their plant, because of security regulations.

Benjamin Dow, Faculty Advisor, accepted the invitation from Allison Division of General Motors Corporation to attend its exhibition and requested April 23, the date we had previously planned to visit North American Aviation.

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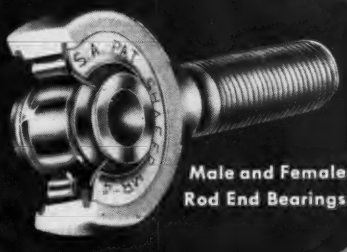

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This picture, taken on February 24 at Cal-Aero Technical Institute, shows *(left to right)*: J. K. Carmody, IAS Student Branch Past-Secretary; H. Bode, IAS Faculty Adviser; A. M. (Tex) Johnston, Boeing Airplane Company; A. Speer, AHP Faculty Adviser; A. J. Victor, Chief Engineer, Cal-Aero; and E. Lundby, IAS Student Branch Chairman.

A movie, *Gas Turbine*, was shown. This film described the various uses of the gas turbine in industries other than the aircraft industry.

Massachusetts Institute of Technology

William J. Pragluski

Secretary-Treasurer

The new officers for the local IAS Student Branch are: Chairman, Alan Lee Zuker; Vice-Chairman, Robert Lee; and Secretary-Treasurer, William J. Pragluski.

The Pennsylvania State University

Ralph N. Straley II, *Secretary*

A regularly scheduled meeting of The Pennsylvania State University Student Branch of the Institute of the Aeronautical Sciences was held on March 24 on the campus, with 30 aeronautical engineers attending. Chairman Frank Leader presided.

The speaker for the meeting was Dr. Herman Kurzweg, Chief of the Aeroballistic Research Department, U.S. Naval Ordnance Laboratory.

Dr. Kurzweg first illustrated the relation between the development of aeronautics and the development of ballistics. He then discussed the development of high-speed missiles and the several obstructions encountered when dealing with missiles at high Mach Numbers. Especially interesting were the methods being experimented with in an effort to solve the problem of high temperatures at high speeds. Dr. Kurzweg's discussion was based upon a group of slides showing wind-tunnel and ballistic-tunnel missile tests. The ballistics tunnel referred to is an airtight 300-ft. tube, which has facilities for taking photographs at intervals along the tube.

United States Naval Academy

Seaborn H. Wade, Jr., *Secretary*

On Wednesday, March 31, Chairman Don Walsh presided over a special meeting for the preliminary reading of technical papers. A. George Cicolani's paper, "Static and Low Speed Thrust in Ram-Jets," was judged the winner, with Duane Bernhart's paper on "Directional Control" a close second. George Heinrich's paper, "Atom Powered Aircraft," was third. The papers were judged on the basis of originality, research, and presentation. The judges included: Capt. P. K. Will, USN, Head, Department of Aviation, and Comdr. W. H. Cullin, USN, AEDO. Midshipman Cicolani represented the Naval Academy at the IAS Student Conference at the Massachusetts Institute of Technology on April 9 and 10.

▶ On April 9, Program Director Linsner Freitag presided over a meeting of some 500 members. A Navy film on the guided missile, Sparrow, and another on the F2H Banshee were shown. The Branch Officers were attending the IAS Student Conference at the time of this meeting.

University of Colorado

Robert G. Lacy

Corresponding Secretary

The IAS Student Branch at the University of Colorado rounded out a busy school year with several spring functions. Our Annual Spring Banquet was held on April 30.

This year, the group is sponsoring an event that has never before been held in Boulder, Colo. This is a city-wide model-airplane meet. The meet will comply with A.M.A. rules, and prizes and trophies will be donated by local business men. A number of townspeople have already shown an interest in entering models in the meet.

The winners of our local Student Paper Competition were Bob Randall, for the Graduate Student Division, and Jim Polosky, for the Undergraduate Division. Bob's paper was entitled "A Short Review of Boundary Layer Theory and Suction Airfoils." Jim's paper was "A New Type of Landing Gear Indicator." They will travel, along with Professor Durham, our Advisor, to Texas for the formal competition.

▶ At the April 16 meeting, the officers of the group for the coming school year were elected. These men are: Chairman, Harvey Gerhard; Vice-Chairman, Jay Burcham; Secretary, Jack Kenney; and Treasurer, Roland Payne. At this meeting, Professor Durham gave a talk on atomic power plants for aircraft.

University of Illinois

John Locke, *Secretary*

The April meeting of the IAS was held on Wednesday evening, April 21, at 7:30. The meeting was called to order and presided over by the Chairman, Dwight Moberg. Minutes of the previous meeting were read, and a financial report was given. Plans for the annual banquet were discussed, as were plans for a picnic.

Following this, an excellent talk was given by Jerome Lederer, Director of the Flight Safety Foundation. The title of his talk was "The State of Air Safety and Its Problems." A survey of the present situation of air safety was presented, with slides showing figures and graphs of various statistics included to give the listeners a more complete picture. The importance of safety was then discussed. This included safety in design and safety in maintenance. It was rather interesting to note the various concepts that can be incorporated by the designer to develop a safer airplane. Accident waste was next discussed to give some magnitude of the cost of accidents to the air lines, not only in terms of human life, but also financially. This rather effectively showed the great need for safe engineering.

Following this, a short program of slides showing recent accidents and their causes was presented. To conclude the program, a motion picture, *Crash*

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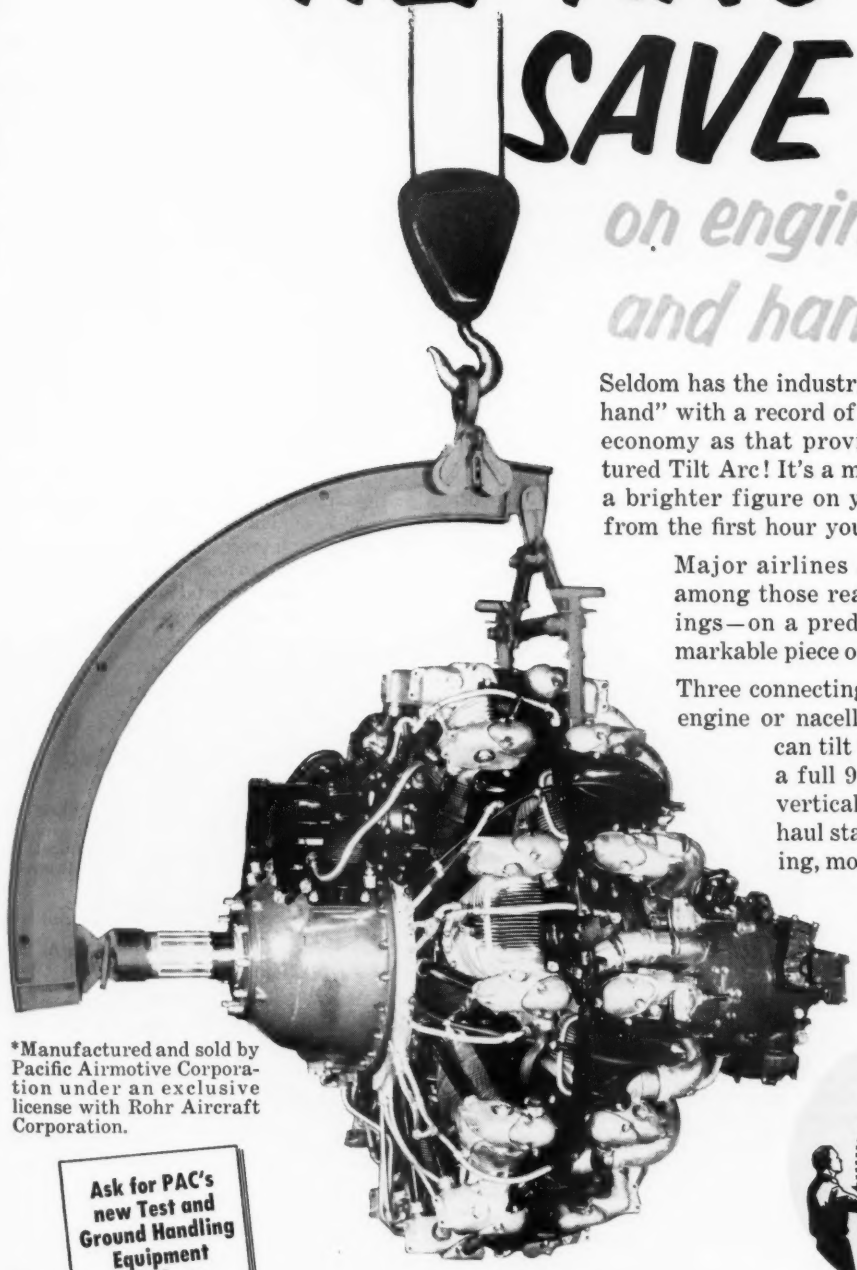

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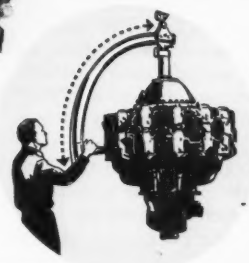

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This picture, taken during a recent field trip to the Tulsa, Okla., facilities of Douglas Aircraft Company, Inc., shows members of the University of Oklahoma IAS Student Branch, two Oklahoma faculty members, and several Douglas-Tulsa personnel. From *left to right* are shown: *front row*, P. Fisher and R. E. Bodner; *middle row*, R. Webb (Douglas), P. Jube, D. Whitten, T. E. Ballinger, S. Whitten, J. S. Webb, C. E. Gregg, and J. Hayes (Douglas); and *back row*, L. A. Comp (Professor of Aeronautical Engineering and Faculty Adviser, Oklahoma), R. Dickenson (Douglas), N. Piercy (Douglas), C. Tuggle, J. Riley (Douglas), R. Pachett, J. K. Loewen, J. E. Godown, E. Anderson, B. V. Ketcham (Chairman, Department of Aeronautical Engineering, Oklahoma), H. Herdon, S. Donovan, and J. L. Johnson (Douglas).

Fire Hazards, was shown. This film was the result of an extensive survey of this problem by the NACA. It included a thorough discussion of the various ways in which fire starts in different types of crashes. The meeting was then brought to a close by the Chairman.

University of Maryland

John J. Gallagher, *Secretary*

The spring semester's activities of the IAS Student Branch at the University of Maryland were initiated with a meeting held on February 18. After a short business meeting, our speaker for the evening, A. L. Berryman, of Boeing Airplane Company's F-99 Pilotless Interceptor Project, was introduced. Mr. Berryman's talk dealt with a subject that was interesting to our student engineers, "Product Diversification in the Aircraft Industry." The speaker discussed the various fields outside of basic air-frame manufacture in which the Boeing Company is active, giving examples in the form of films on the 502 Gas Turbine, in-flight refueling systems, and Boeing's research in the field of guided missiles. Specific aspects of these subjects were covered by Mr. Berryman in an open discussion at the conclusion of his talk.

▶ On April 13, the Student Branch held its Annual Banquet at the Stone House Inn in Silver Spring, Md. At the conclusion of the dinner our speakers, Jack Perine and Col. Floyd Sweet, of the Mid-Atlantic Soaring Association, were introduced. Colonel Sweet led off the evening's program with a brief history of gliding from ancient Greek mythology to the present day, pointing out that much of the research leading to powered flight was accomplished with gliders. A film illustrating some of actual flying techniques used in gliding followed Colonel Sweet's talk.

Mr. Perine's discussion of the practical aspects of soaring comprised the latter part of the program. At the conclusion of the talks, the members were invited by the speakers to the gliding field at Martinsburg, W. Va., for a day of soaring. The members plan to go as a group on the week end of May 30.

▶ The meeting of April 27 featured Norman Hubbard, Assistant Chief Engineer, Electro-Mechanical Branch, Engineering Research Corporation, as our speaker. Mr. Hubbard's topic was "The Aeronautical Engineer's Place in the Field of Flight Simulation." The speaker began his talk with a summary of the work presently being done by his company in flight simulating and training equipment. He described the part that the various engineers, aeronautical, mechanical and electrical, play in the design and manufacture of this equipment. The simulators are basically analog computers solving flight-condition equations from the machine's controls and sending answer signals back to the instrument panel. The aeronautical engineer's job is to break down flight-condition data into equation form for the computer. The simulators themselves have reached a high degree of realism, being able to imitate actual sound, light, and control conditions encountered in flight. Mr. Hubbard concluded his discussion by mentioning some of the ideas, such as televised flight paths, that may be incorporated in future simulators.

▶ The last meeting of the 1954 spring semester was held on May 4. The election of officers for the fall term was carried out, and the results were as follows: William S. Sekscienski, Chairman; C. G. Stouffer, Vice-Chairman; George Maggos, Secretary; John B. Clark, Treasurer; and R. M. Rivello, Faculty Advisor.

▶ The activities of this Student Branch were concluded for the school year with the annual picnic on May 22.

University of Oklahoma

Ernest Z. Anderson, *Secretary*

Members of the University of Oklahoma IAS Student Branch recently visited the Tulsa plant of Douglas Aircraft Company, Inc. The purpose of the trip was to familiarize the Student Members, all Aeronautical Engineering students, with the operations of a large aircraft company.

As guests of Douglas, the group was taken on a guided tour of the plant facilities. The tour started in the plant shops and proceeded on through process engineering to final assembly. Members of the group were taken out on the flight line for a look at the B-47 Stratofortress, assembled at Tulsa under contract from Boeing Airplane Company.

Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Goethert, Bernhard H., Ph.D. in Ae.E., Chief, Propulsion Wind Tunnel Div., ARO, Inc.

Stevenson, Clinton H., S.M., Chief, Strength & Weight Section, Douglas Aircraft Co., Inc. (El Segundo).

Transferred to Associate Fellow Grade

Corrsin, Stanley, Ph.D., Assoc. Prof. of Aeronautics, The Johns Hopkins Univ.

Haar, Marvin I., M.S., Chief, Water-Based Aircraft & High Speed Surface Craft Hydrodynamics, Exp. Towing Tank, Stevens Institute of Technology.

Piatelli, Fidia J., Ph.D.Ae.E., Aero. Advisor, Design & Research Branch, Ministry of Defence—State of Israel.

Wheaton, Elmer P., B.A., Chief Proj. Engr., Missiles, Douglas Aircraft Co., Inc. (Santa Monica).

Woersching, Thomas B., LL.B.; M.S. Ae.E., Mgr., Aerodynamics & Thermodynamics Dept., Goodyear Aircraft Corp.

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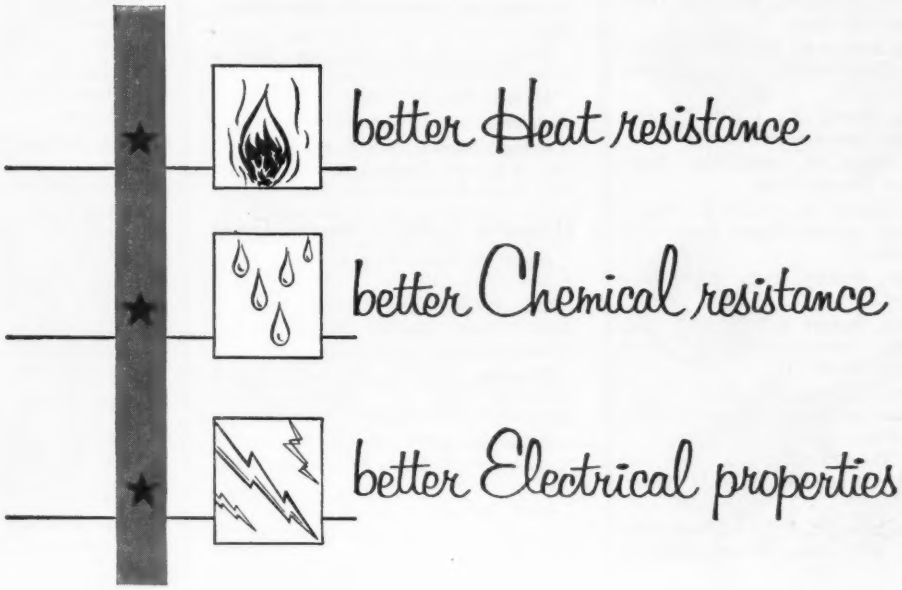

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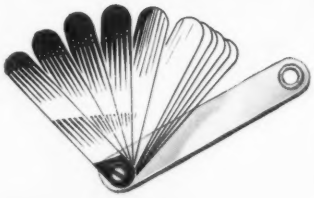

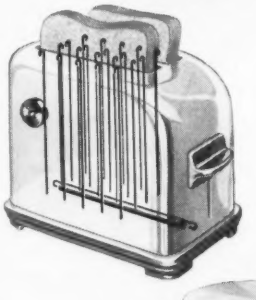

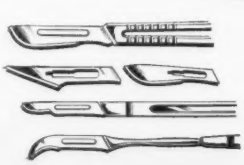

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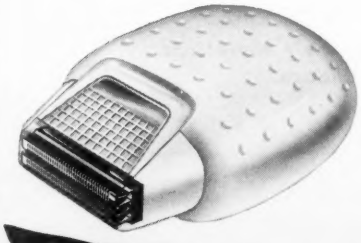

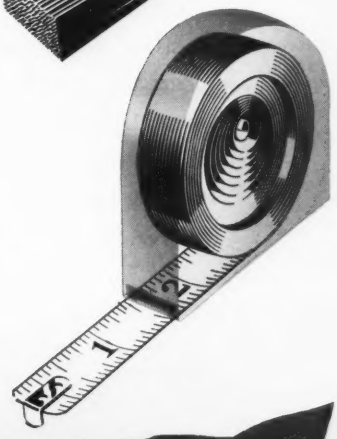

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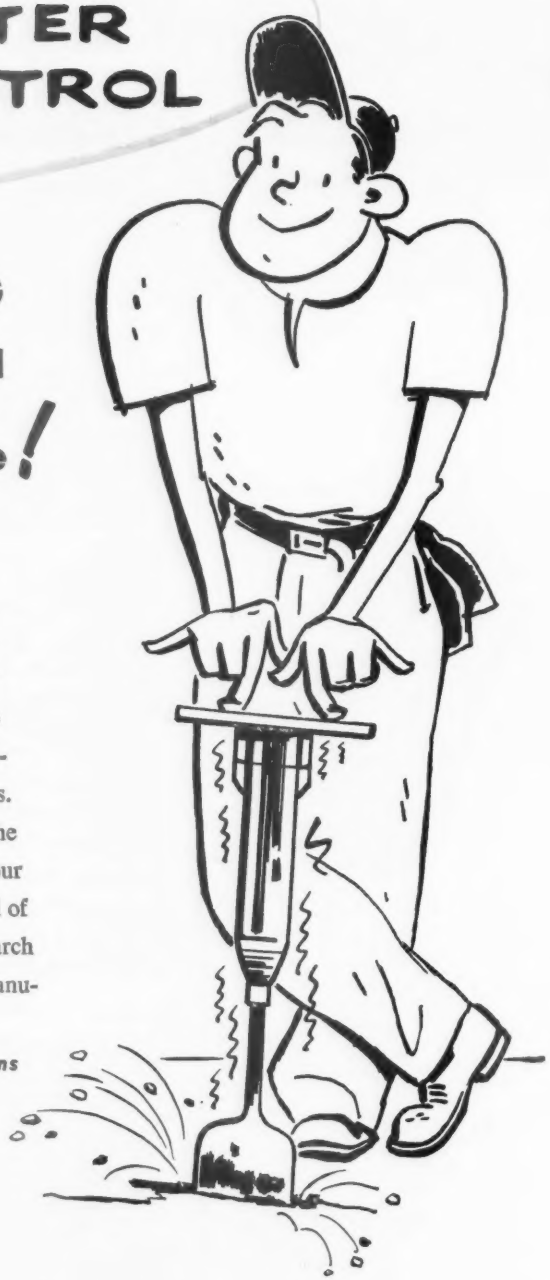

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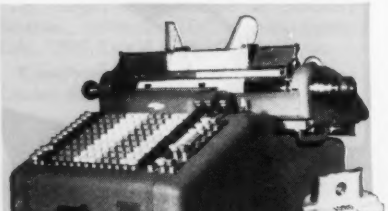

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Aeronautical Reviews

A Guide to the Current Literature of Aeronautical Research and Engineering

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A&M Coll. Tex. Eng. Exp. Sta. Res. Rep. Agricultural and Mechanical College of Texas, Texas Engineering Experiment Station, Research Report

Acta Polytechnica (Stockholm)

Aero Dig. Aero Digest

Aero. Eng. Rev. Aeronautical Engineering Review

Aero. Quart. The Aeronautical Quarterly

Aero Res. TN; Bul. Aero Research Technical Notes; Bulletin

Aerodynamisches Inst. Tech. Hochschule, Braunschweig, Bericht. Aerodynamisches Institut der Technischen Hochschule, Braunschweig, Bericht

Aeronautics

The Aeroplane

L'Aerotecnica (Rome)

Aerovox Res. Worker. Aerovox Research Worker

AHS Papers. American Helicopter Society, Papers

AIAA Papers. Aircraft Industries Association of America, Papers

AIEE Papers. American Institute of Electrical Engineers, Papers

Air Facts

Air Force

Air Line Pilot

Air Pictorial

Air Rev. Air Revue (Brussels)

Air Transp. Air Transportation

Air U. Quart. Rev. Air University Quarterly Review

Airborne Instr. Lab. Proj. Rep. Airborne Instruments Laboratory, Project Report

Aircraft (Australia)

Aircraft (Canada)

Aircraft Eng. Aircraft Engineering

Aircraft Heating Dig. Aircraft Heating Digest

Aircraft Prod. Aircraft Production

Airport Operators Council, Papers

Airports & Air Transp. Airports & Air Transportation

Allis-Chalmers Elec. Rev. Allis-Chalmers Electrical Review

ALPA Papers. Air Line Pilots Association, Papers

Aluminium Devel. Assn. Res. Rep. Aluminium Development Association, Research Reports (London)

Am. Av. American Aviation

Am. Helicopter. American Helicopter

Am. J. of Phys. American Journal of Physics

Anal. Chem. Analytical Chemistry

Antiaircraft J. Antiaircraft Journal

Appl. Hydraulics. Applied Hydraulics

Appl. Mech. Rev. Applied Mechanics Reviews

Appl. Sci. Res., Sect. A. Applied Scientific Research, Section A (Mechanics, Heat, Chemical Engineering, Mathematical Methods)

Appl. Sci. Res., Sect. B. Applied Scientific Research, Section B (Electrophysics, Acoustics, Optics, Mathematical Methods)

Arch. Mech. Stosowanej (Warsaw). Archiwum Mechaniki Stosowanej, Zakład Mechaniki Ośrodków Ciagłych Polskiej Akademii Nauk (Warsaw, Poland)

Argonne Natl. Lab. Rep. Argonne National Laboratory, Reports

ASCE Air Transp. Div. Papers; Preprints. American Society of Civil Engineers, Air Transport Division, Papers; Preprints

ASME Preprints; Papers. American Society of Mechanical Engineers, Preprints; Papers

ASTM Bul. American Society for Testing Materials, Bulletin

ATA Papers. Air Transport Association (of America), Papers

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Australia, ARL EN; IN; Rep.; S&M Monogr.; S&M TM; Notes. Australia, Department of Supply, Aeronautical Research Laboratories, Engines Note; Instruments Note; Reports; Structures and Materials Monographs; Structures and Materials Technical Memorandum; other Notes

Australia, CSID Aero. Res. Rep. Australia, Council for Scientific and Industrial Research, Aeronautical Research Report

Australian J. of Appl. Sci. Australian Journal of Applied Science

Australian J. Phys. Australian Journal of Physics [formerly Australian Journal of Scientific Research, Series A (Physical Sciences)]

Auto. Ind. Automotive Industries

Auto-Technik (Berlin)

Av. Age. Aviation Age

Av. Week. Aviation Week

Aviaçao (Rio de Janeiro)

Bearing Engr. Bearing Engineer

Bee Hive

Bell Aircraft Rep. Bell Aircraft Corporation, Reports

Bell System Tech. J. Bell System Technical Journal

Bendix Av. Eng. Rep. Bendix Aviation Corporation, Engineering Reports

Boeing Mag. Boeing Magazine

Brit. Aircraft Ind. Bul. British Aircraft Industry Bulletin

Brit. J. Appl. Phys. British Journal of Applied Physics

Brit. Welding J. British Welding Journal

Brown-Boveri Rev. Brown-Boveri Review

Bul. AMS. Bulletin of the American Meteorological Society

Bus. Flying. Business Flying

Canada, NAE HSAL Rep. Canada, National Aeronautical Establishment, High Speed Aerodynamics Laboratory, Reports

Canada, NAE LR; Note; Quart. Bul.; Rep. Canada, National Aeronautical Establishment, Laboratory Report; Note; Quarterly Bulletin; Reports

Canada, NRC Div. Mech. Eng. Rep. Canada, National Research Council, Division of Mechanical Engineering, Reports

Canada, RCAF, Rockcliffe, Rep. Canada, Royal Canadian Air Force, Rockcliffe, Reports

Can. Airline Pilot. Canadian Airline Pilot

Can. Av. Canadian Aviation

Can. J. Phys. Canadian Journal of Physics

Can. J. Tech. Canadian Journal of Technology

CEC Recordings

Chartered Mech. Engr. The Chartered Mechanical Engineer (London)

Chrysler Eng. Div. Rep. Chrysler Corporation, Engineering Division, Reports

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CIT Jet Propulsion Lab. Prog. Rep. California Institute of Technology, Jet Propulsion Laboratory, Progress Reports

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Engine-control electronic equipment is frequently installed in close proximity to the turbojet engine. Therefore, electronic components must be designed and constructed to function with *complete reliability* under extreme ambient conditions. However, the degree of reliability attained depends largely upon the attention given to detail in applying these five major design principles to every phase of equipment development:

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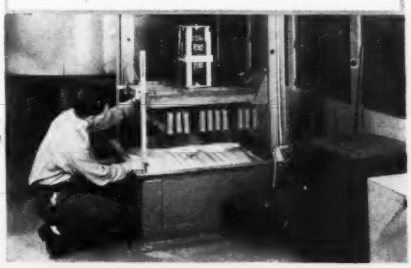
2. Rugged design of mechanical details.
3. Selection of components based upon extensive environmental and life tests.
4. Operation of all components well below their maximum rating.
5. Adequate performance tests of production units under dynamic operating conditions.

Strict adherence to these principles has enabled us to achieve extreme reliability in all our aircraft electronic equipment. We believe our years of concentrated research, development and tests devoted exclusively to automatic control systems for jet engines can be of real value in solving your control problems. Our engineering counsel and extensive manufacturing and test facilities are at your service. We welcome your inquiry.

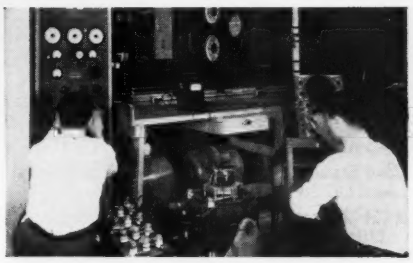
TEMPERATURE CONTROL AMPLIFIER (*Illustrated above*). Modulates exhaust nozzle area of a turbojet engine to maintain a constant turbine exit temperature. Input signal is derived from thermocouples. Output controls a servo which supplies hydraulic power to the exhaust nozzle positioning actuators.

TEST SPECIFICATIONS. **MIL-E-5009A:** Altitude, ignition proof, sand and dust, humidity, sustained acceleration, impact. **MIL-E-5272A:** Salt Spray. **MIL-E-5007A:** General specification. **MIL-I-6181:** Radio interference.

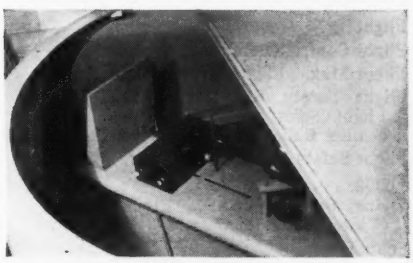
SIMULATED OPERATING CONDITIONS PROVE COMPONENT PERFORMANCE



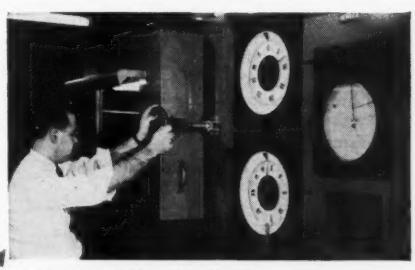
IMPACT. Unit must withstand impact shocks of 30g for a time duration of not less than 10 milliseconds.



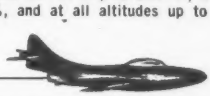
VIBRATION. Operational accuracy guaranteed at 5g from 20 to 55cps and at 10g from 55 to 225cps.



SUSTAINED ACCELERATION. Unit must operate satisfactorily while subjected to sustained acceleration of 8g along its longitudinal axis, 10g along its vertical axis, and 5g along its horizontal axis.



FLIGHT TEST CHAMBER. Unit performance checked under simulated flight conditions within a temperature range of minus 65° F. to plus 200° F., a relative humidity of 95%, and at all altitudes up to 50,000 feet.



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Corrosion

Curtiss-Wright Corp., Wright Aero. Div., Rep. Curtiss-Wright Corporation, Wright Aeronautical Division, Reports

de Havilland Gazette

Dickinson Law Rev. Dickinson Law Review

Douglas Rep. Douglas Aircraft Company, Inc., Reports

Douglas Serv. Douglas Service

Elec. Commun. Electrical Communication

Elec. Eng. Electrical Engineering

Elec. Mfg. Electrical Manufacturing

Electronic Eng. Electronic Engineering

Electronics

Electronics Forum. See: Proc. Inst. Electronics

Eng. J. Engineering Journal

The Engr. The Engineer

Engr. Dig. Engineer's Digest

Escher Wyss News

Esso Air World

Esso Standard Oil Co. Rep. Esso Standard Oil Company, Reports

ETH Inst. für Aerodynamik (Zurich), Mitteilungen. Eidgenössische Technische Hochschule, Institut für Aerodynamik (Zurich), Mitteilungen

Fasteners

Flight

Flight Control (Bendix)

Flight Mag. Flight Magazine

Flight Safety Foundation Mech. Bul. Flight Safety Foundation, Inc., Mechanics Bulletin

Flight Safety Foundation, Papers

Flying

Flying Safety (USAF). Flying Safety (United States Air Force)

Foote Prints

France, Min. de l'Air BST; NT; PST. France, Ministère de l'Air, Bulletin des Services Techniques; Notes Techniques; Publications Scientifiques et Techniques

France, ONERA Pubs. France, Office National d'Études et de Recherches Aéronautiques, Publications

Franklin Inst. Labs. TR. Franklin Institute Laboratories for Research and Development, Technical Reports

The Frontier

Fulmer Res. Inst. Rep. Fulmer Research Institute Limited, Reports

GALCIT Memo. Guggenheim Aeronautical Laboratory, California Institute of Technology, Pasadena, Calif., Memorandums

Garbell Res. Foundation, Aero. Ser. Garbell Research Foundation, Aeronautical Series

G-E Rev. General Electric Review

Gen. Radio Exp. General Radio Experimenter

GM Eng. J. General Motors Engineering Journal

Goodyear Aircraft Corp. Rep. Goodyear Aircraft Corporation, Reports

Gt. Brit., AAEE Rep. Great Britain, Aeroplane and Armament Experimental Establishment, Boscombe Down, Reports

Gt. Brit., AERE Rep. Great Britain, Atomic Energy Research Establishment, Reports

Gt. Brit., ARC CP. Great Britain, Aeronautical Research Council, Current Papers

Gt. Brit., ARC R&M. Great Britain, Aeronautical Research Council, Reports & Memoranda

Gt. Brit., Meteorological Off. Prof. Notes & Reps. Great Britain, Meteorological Office, Professional Notes and Reports

Gt. Brit., MOS DGC TIB Rep. & Transl. Great Britain, Ministry of Supply, Government Defense Council, Technical Information Bureau, Reports and Translations

Gt. Brit., NGTE Rep. Great Britain, National Gas Turbine Establishment, Reports

Gt. Brit., NPL Aerodynamics Div. Rep. Great Britain, National Physical Laboratory, Aerodynamics Division, Reports

Gt. Brit., RAE FPRC Rep. Great Britain, Royal Aircraft Establishment, Flying Personnel Research Committee, Reports

Gt. Brit., RAE Rep. Great Britain, Royal Aircraft Establishment, Reports

Gt. Brit., RAE TN. Great Britain, Royal Aircraft Establishment, Technical Notes

Handley-Page Bul. Handley-Page Bulletin

Harvard U. Cruft Lab. TR. Harvard University, Cruft Laboratory, Technical Reports

Hawker Siddeley Rev. Hawker Siddeley Review

Hewlett-Packard J. Hewlett-Packard Journal

Hunting Group Rev. Hunting Group Review

Hydraulic Engr. Hydraulic Engineer

IAS Preprints; Papers. Institute of the Aeronautical Sciences, Preprints; Papers

IATA Bul. International Air Transport Association Bulletin

ICAO Bul. International Civil Aviation Organization Bulletin

IME Auto. Div. Proc. Institution of Mechanical Engineers, Automobile Division, Proceedings

IME Proc. (A). Institution of Mechanical Engineers, Proceedings (A)

IME Proc. (B), Appl. Mech.; Hydraulics. Institution of Mechanical Engineers, Proceedings (B), Applied Mechanics; Hydraulics

INCO. (International Nickel Company, Inc.)

Ind. & Eng. Chem. Industrial and Engineering Chemistry

Ind.-Anzeiger. Industrie-Anzeiger (Essen, Germany)

Ind. Quality Control. Industrial Quality Control

Ind. Sci. & Eng. Industrial Science and Engineering (Advanced-student edition of *Industrial Laboratories*)

Indian AF Quart. Indian Air Force Quarterly

Indian Airman

Indian Skyways

Institut Français du Transport Aérien, Res. Papers. Institut Français du Transport Aérien, Research Papers

Instrumentation

Instruments & Automation

Interavia (Monthly)

Interchem. Rev. Interchemical Review

Internatl. Nickel Devel. & Res. Div. Tech. Bul. International Nickel Company, Development & Research Division, Technical Bulletins

Ireland, Meteorological Serv., Geophys. Pubs. Ireland, Meteorological Service, Geophysical Publications

ISA J. Instrument Society of America Journal. In: **Instruments**

Istanbul Tech. U. Bul. Istanbul Technical University, Bulletin

J. Acoustical Soc. Am. Journal of the Acoustical Society of America

J. ACS. Journal of the American Chemical Society

J. Aero. Sci. Journal of the Aeronautical Sciences

J. Aero. Soc. India. Journal of The Aeronautical Society of India

J. Air Law & Commerce. Journal of Air Law & Commerce

J. Appl. Mech. Journal of Applied Mechanics

J. Appl. Phys. Journal of Applied Physics

J. ARS. Journal of the American Rocket Society. See **Jet Propulsion**

J. ASNE. Journal of the American Society of Naval Engineers

J. Atmos. & Terrestrial Phys. Journal of Atmospheric & Terrestrial Physics

J. Av. Med. Journal of Aviation Medicine

J. Brit. Interplanetary Soc. Journal of the British Interplanetary Society

J. Electrodepositors' Tech. Soc. Journal of the Electrodepositors' Technica' Society

J. Eng. Educ. Journal of Engineering Education

J. Exp. Biol. The Journal of Experimental Biology

J. Franklin Inst. Journal of the Franklin Institute

J. GAPAN. Journal of the Guild of Air Pilots and Air Navigators

J. Helicopter Assn. Gt. Brit. Journal of the Helicopter Association of Great Britain

J. Hokkaidô Gakugei U., Sect. B. Journal of Hokkaidô Gakugei University, Section B (Japan)

J. Indian Inst. Sci. Journal of the Indian Institute of Science

J. Inst. Metals. Journal of the Institute of Metals

J. Inst. Navigation. Journal of the Institute of Navigation

J. Inst. Transp. Journal of the Institute of Transport

J. Japan Soc. Appl. Mech. Journal of the Japan Society for Applied Mechanics

J. London Math. Soc. Journal of the London Mathematical Society

J. Math. & Phys. Journal of Mathematics and Physics

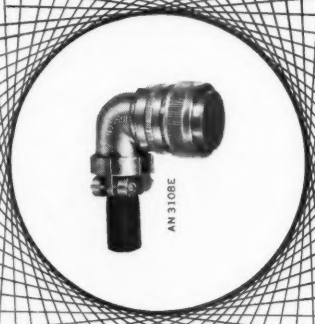
J. Mech. & Phys. Solids. Journal of the Mechanics and Physics of Solids

J. Meteorology. Journal of Meteorology

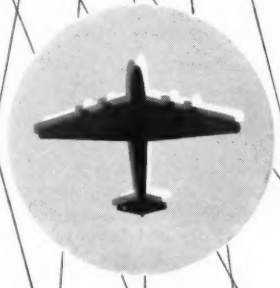
J. RAeS. Journal of the Royal Aeronautical Society

J. Sci & Ind. Res. Journal of Scientific and Industrial Research

J. Sci. Instr. Journal of Scientific Instruments



vibration resistant



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J. Sci. Res. Journal for Scientific Research

J. SCMA. Journal of the Southern California Meter Association. In: **Instruments**

J. SLAE. Journal of the Society of Licensed Aircraft Engineers (incorporating The Technical Instructor)

J. Southern Res. Journal of Southern Research

J. Space Flight. Journal of Space Flight

Japan, NCB Rep. Japan, Numerical Computation Bureau, Reports

Japan Sci. Rev. Japan Science Review (Engineering Sciences)

Jet Age

Jet Propulsion. (Formerly, J. ARS)

Konstruktion (Germany)

Kyushu U., Japan, Rep. Res. Inst. Appl., Mech. Kyushu University, Japan, Reports of Research Institute for Applied Mechanics

La. State U. Eng. Exp. Sta. Bul. Louisiana State University, Engineering Experiment Station, Bulletin

Lenkurt Demodulator

Lockheed Aircraft Rep. Lockheed Aircraft Corporation, Reports

The Log

Lubrication

Lubrication Eng. Lubrication Engineering

Mach. Des. Machine Design

Mag. of Magnesium. Magazine of Magnesium

Mag. of Standards. The Magazine of Standards

Marconi Rev. Marconi Review

Martin Star

Materials & Methods

Mech. Eng. Mechanical Engineering

Mech. Engr. (India). Mechanical Engineer, Bangalore, India (Journal of the Mechanical Engineering Society, Indian Institute of Science)

Metal Treatment

Metall (Berlin)

Metallurgia

Metallurgia Italiana (Milan)

Meteorological Mag. The Meteorological Magazine

Mil. Surgeon. Military Surgeon

Miss. State U. Eng. Res. Sta. Res. Rep. Mississippi State University, Engineering Research Station, Research Reports

Mitteil. Hydraulischen Inst. Tech. Hochschule, München. Mitteilungen des Hydraulischen Instituts der Technischen Hochschule, München

Mitteil. Max-Planck-Inst. für Strömungsforschung. Mitteilungen aus dem Max-Planck-Institut für Strömungsforschung (Göttingen)

Modern Metals

Motorola Newsgram

N.C. State Coll. Eng. Sch. Bul. North Carolina State College, Engineering School Bulletin

Natl. Acad. Sci. NRC Rep. National Academy of Sciences of the United States, National Research Council, Reports

Natl. Assn. State Av. Off. Papers. National Association of State Aviation Officials, Papers

NATO AGARD Memo. North Atlantic Treaty Organization, Advisory Group for Aeronautical Research and Development, Memorandum

Naval Av. News. Naval Aviation News

Navigation

Netherlands, Mathematisch Centrum, Amsterdam, Rep. (Reports)

Netherlands, NLL Rep. (Rep. & Trans.) Netherlands, Nationaal Luchtvaartlaboratorium (National Aeronautical Research Institute), Amsterdam, Reports (Reports and Transactions)

New Frontiers

New Zealand Flying

NFPA Bul.; Papers; Rep. National Fire Protection Association, Bulletins; Papers; Reports

NFPA Comm. Av. & Airport Fire Protection Bul.; Rep. National Fire Protection Association, Committee on Aviation and Airport Fire Protection, Bulletins; Reports

North Amer. Av. Spec. Res. Rep. North American Aviation Corporation, Special Research Reports

NYU Res. Rev. New York University, College of Engineering, Research Review

O. State U. Eng. Exp. Sta. News. The Ohio State University, Engineering Experiment Station, News

Ordnance

Ore. State Coll. Eng. Exp. Sta. Bul. Oregon State College, Engineering Experiment Station, Bulletin

Organic Finishing

The Oscillographer

Pacific J. Math. Pacific Journal of Mathematics

Papers in Meteorology & Geophys. Papers in Meteorology and Geophysics

Pegasus

Philips Tech. Rev. Philips Technical Review

Philos. Mag. Philosophical Magazine

Philos. Trans. Royal Soc. (London), Ser. A. Philosophical Transactions of the Royal Society of London, Series A, Mathematical and Physical Sciences

Photogrammetria

Photogrammetric Eng. Photogrammetric Engineering

Photographic Eng. Photographic Engineering

Power Jets Memo. Power Jets (Research and Development) Limited, Memorandum

Princeton U. Dept. Aero. Eng. Rep. Princeton University, Department of Aeronautical Engineering, Reports

Proc. Cambridge Philos. Soc. Proceedings Cambridge Philosophical Society

Proc. IEE, Part I. Proceedings of the Institution of Electrical Engineers, Part I (General)

Proc. IEE, Part II. Proceedings of the Institution of Electrical Engineers, Part II (Power Engineering)

Proc. IEE, Part III. Proceedings of the Institution of Electrical Engineers, Part III (Radio and Communication Engineering)

Proc. Inst. Electronics. Proceedings of the Institution of Electronics (Electronics Forum)

Proc. IRE. Proceedings of the Institute of Radio Engineers

Proc. London Math Soc., 2nd Ser.; 3rd Ser. Proceedings of the London Mathematical Society, 2nd Series; 3rd Series

Proc. Phys. Soc., Sect. B. Proceedings of the Physical Society (British), Section B

Proc. Royal Netherlands Acad. Sci., Amsterdam, Ser. A; Ser. B; Ser. C. Proceedings of the Royal Netherlands Academy of Sciences at Amsterdam, Series A (Mathematical Sciences); Series B (Physical Sciences, containing, e.g., Astronomy, Chemistry, Geology, Physics, Technical Sciences); Series C (Biological and Medical Sciences)

Proc. Royal Soc. (Edinburgh). Proceedings of the Royal Society (Edinburgh)

Proc. Royal Soc. (London), Ser. A. Proceedings of the Royal Society (London), Series A (Mathematical and Physical Sciences)

Prod. Eng. Product Engineering

Prof. Engr. Professional Engineer

Purdue U. TR. Purdue University, Technical Reports

Quadrangle

Quart. Appl. Math. Quarterly of Applied Mathematics

Quart. J. Mech. & Appl. Math. Quarterly Journal of Mechanics and Applied Mathematics

Quart. J. Royal Meteorological Soc. Quarterly Journal of the Royal Meteorological Society

Radio & TV News. Radio & Television News

Radio-Electronic Eng. Sect. Radio-Electronic Engineering Section, In: **Radio & TV News**

Radio Tech. Comm. Aeronautics, Papers. Radio Technical Commission for Aeronautics, Papers

RAND Corp. Transl. The RAND Corporation, Translations

RCA Rev. RCA Review

La Recherche Aéronautique (Paris)

Republic Av. Rep. Republic Aviation Corporation, Reports

Res. Trends (Cornell Aero. Lab.). Research Trends (Cornell Aeronautical Laboratory, Inc.)

Rev. Sci. Instr. Review of Scientific Instruments

Revista de Aeronáutica (Madrid)

Revista Nacional de Aeronautica (Buenos Aires)

Reynolds Metals Tech. Adviser. Reynolds Metals Technical Adviser

La Ricerca Sci. La Ricerca Scientifica (Rome)

Rivista Aeronautica (Rome)

Rockets

Rolls-Royce Bul. Rolls-Royce Bulletin

Ryan Reporter

Saab Sonics (Sweden)

Saab TN. Saab Technical Notes

SAE Aero. Info. Rep. Society of Automotive Engineers, Aeronautical Information Report

SAE J. SAE Journal

SAE Preprints; Papers. Society of Automotive Engineers, Preprints; Papers

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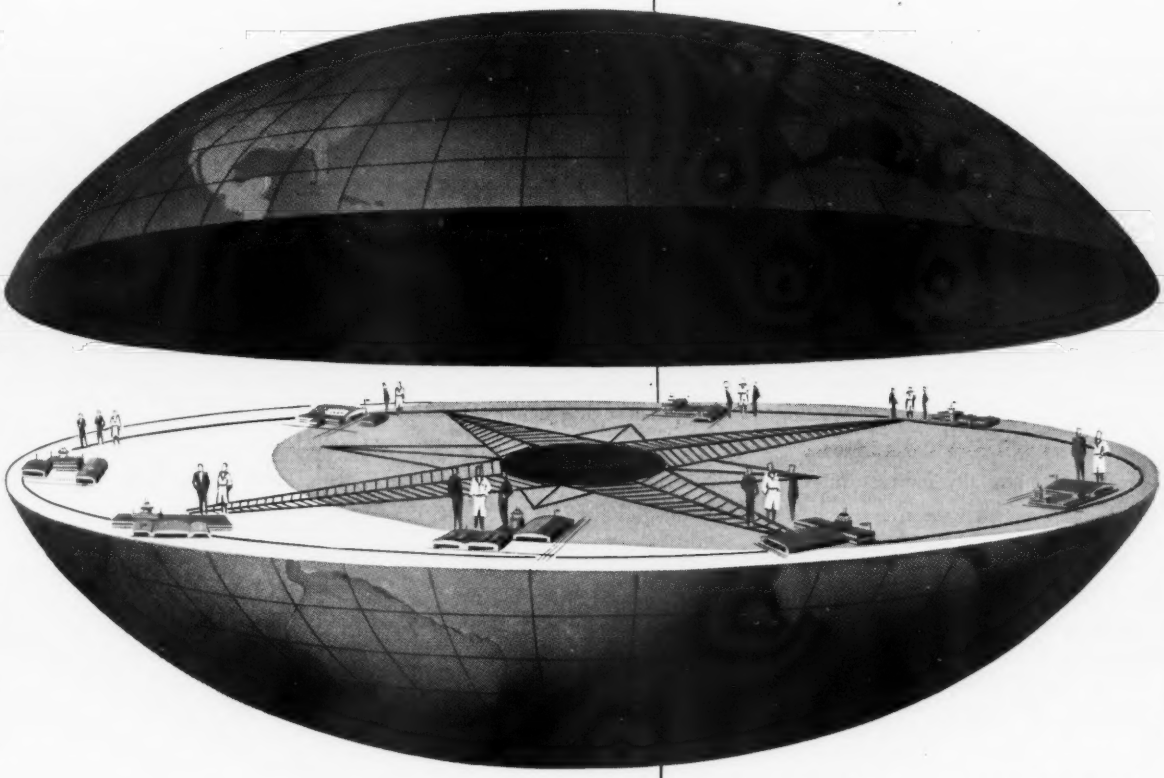

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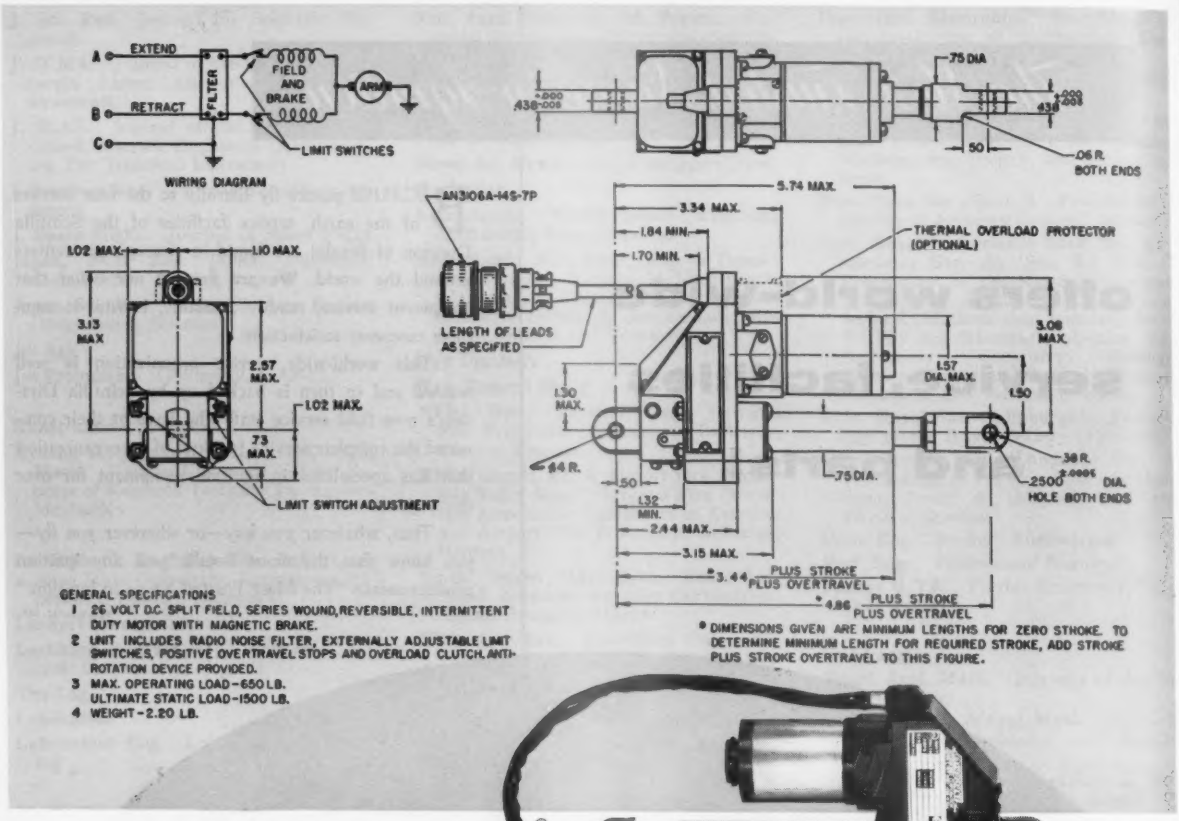
Export Sales: Bendix International Division
205 East 42nd St., New York 17, N. Y.



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2. Is it consistent with airframe design in weight and size?
3. Will it meet your standard of reliability?

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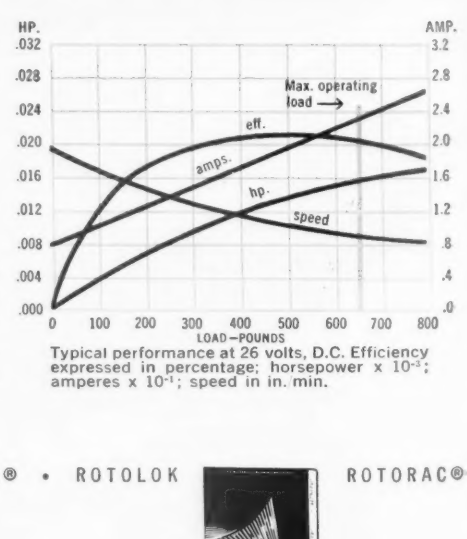

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Sailplane & Glider

Saro Prog. Saro Progress

Sci. Mo. The Scientific Monthly

Science

Sheet Metal Ind. Sheet Metal Industries

Shell Av. News. Shell Aviation News

Skyline. (North American Aviation, Inc.)

Skyways

SNCASO Papers. Société Nationale de Constructions Aéronautiques du Sud-Ouest, Papers

Soaring

Solar Blast

SPE J. Society of Plastics Engineers, Journal

Sperry Gyroscope Rep. Sperry Gyroscope Company, Reports

Sperry Rev. Sperry Review

Sperryscope

Stanford Res. Inst. Res. Ind. Stanford Research Institute, Research for Industry

State Coll. Ia. Eng. Exp. Sta. TR. State College of Iowa, Engineering Experiment Station, Technical Reports

Steel Horizons

Steel Processing

Stockholm, KTH AERO TN. Stockholm, Kungliga Tekniske Högskola, Institutionen för Flygteknik, Technical Notes

Stockholm, KTH IBS Medd. Stockholm, Kungliga Tekniska Högskolan, Institutionen för Byggnadsstatik, Meddelanden

Structural Engr. Assn. Calif. Rep. Structural Engineers Association of California, Reports

Sverdrup & Parcel Transl. Rep. Sverdrup & Parcel, Inc., Translation Reports

Sweden, Flygtekniska Försöksanstalten, FFA Medd. (The Aeronautical Research Institute of Sweden, Reports)

Syracuse U. Transp. Conf. Papers. Syracuse University, Transportation Conference, Papers

Taylor Tech. Taylor Technology

Tech. et Sci. Aéronautiques. Technique et Science Aéronautiques (Paris)

Tech. Rev. Technology Review

Teknisk Ukeblad (Norway)

Tele-Tech

Tôhoku U. (Japan) Rep. Inst. High Speed Mech. Tôhoku University, Sendai, Japan, The Reports of the Institute of High Speed Mechanics. The Science Reports of the Research Institutes, Series B (Technology)

Tool Engr. Tool Engineer

Trans. AIEE. Transactions of the American Institute of Electrical Engineers

Trans. ASME. Transactions of the American Society of Mechanical Engineers

Trans. Inst. Welding. Transactions of the Institute of Welding

Trans. IRE Prof. Group on Microwave Theory & Techniques. Transactions of the Institute of Radio Engineers, Professional Group on Microwave Theory and Techniques

Trans. Soc. Inst. Tech. Transactions of the Society of Instrument Technology

Transp. & Commun. Rev. Transport and Communications Review

Transport (India)

Trend in Eng. The Trend in Engineering

U. Ark. Engr. Exp. Sta. Bul. University of Arkansas, Engineering Experiment Station, Bulletin

U. Calif. Pubs. in Eng. University of California, Publications in Engineering

U. Ill. Bul. University of Illinois, Bulletins

U. Ill. Eng. Exp. Sta. Bul.; TR. University of Illinois, Engineering Experiment Station, Bulletins; Technical Reports

U. Md. Inst. Fluid Dynamics & Appl. Math., Lecture Ser. University of Maryland, Institute for Fluid Dynamics and Applied Mathematics, Lecture Series

U. Mich. Eng. Res. Inst. Rep. University of Michigan, Engineering Research Institute, Reports

U. Minn. Inst. Tech. Dept. Aero. Eng., Res. Rep. University of Minnesota, Institute of Technology, Department of Aeronautical Engineering, Research Reports

U. Toronto Inst. Aerophys. Rev.; Rep. University of Toronto, Institute of Aerophysics, Review; Reports

U. Wash. Eng. Exp. Sta. Bul.; Reprints. University of Washington, Engineering Experiment Station, Bulletins; Reprints

U. Wis. NRL Dept. Chem. Rep. University of Wisconsin, Naval Research Laboratory, Department of Chemistry, Reports

United Air Lines News

U.S., Bur. Mines Bul.; Rep. Invest. United States, Bureau of Mines, Bulletin; Report of Investigations

U.S., CAA TDR. United States, Civil Aeronautics Administration, Technical Development Reports

U.S., Forest Prod. Lab. Rep. United States, Forest Products Laboratory, Madison, Wis., Reports

U.S., NACA Rep.; RM: TM; TN. United States, National Advisory Committee for Aeronautics, Report; Research Memorandum; Technical Memorandum; Technical Notes

U.S., NADC Rep. U.S., Naval Air Development Center, Reports

U.S., NAES Rep. United States, Naval Air Experiment Station, Reports

U.S., NAVORD Rep. United States, Naval Ordnance, Reports

U.S., Navy Dept. BuAer RDR. United States, Navy Department, Bureau of Aeronautics, Research Division Reports

U.S., Navy Dept., David W. Taylor Model Basin, Rep.; Transl. United States, Navy Department, David W. Taylor Model Basin, Reports; Translations

U.S., NBS J. Res. United States, National Bureau of Standards, Journal of Research

U.S., NBS Sum. TR. United States, National Bureau of Standards, Summary Technical Reports

U.S., NBS Tech. News Bul. United States, National Bureau of Standards, Technical News Bulletin

U.S., NRL Rep. United States, Naval Research Laboratory, Reports

U.S., ONR Res. Rep. United States, Office of Naval Research, Research Report (monthly)

U.S., ONR Special Devices Cen. TR. United States, Office of Naval Research, Special Devices Center, Technical Reports

U.S., Weather Bur. Mo. Weather Rev. United States, Weather Bureau, Monthly Weather Review

U.S. AEC Rep. United States Atomic Energy Commission, Reports

U.S. Air Serv. U.S. Air Services

U.S. Armed Forces Med. J. United States Armed Forces Medical Journal

U.S. Naval Inst. Proc. United States Naval Institute, Proceedings

U.S. Steel Lubricants Testing Lab. Rep. United States Steel Lubricants Testing Laboratory, Reports

USAF AMC Eng. Div. Aero Med. Lab. TR. United States Air Force, Air Materiel Command, Engineering Division, Aero Medical Laboratory, Technical Reports

USAF APG Rep. United States Air Force, Air Proving Ground, Reports

USAF Arctic Aeromed. Lab. Project Rep. United States Air Force, Arctic Aeromedical Laboratory, Alaska, Project Reports

USAF MATS Rep.; Papers. United States Air Force, Military Air Transport Service, Reports; Papers

USAF SAM Rep. United States Air Force, School of Aviation Medicine, Reports

USAF TR. United States Air Force, Technical Reports

Va. J. Sci. The Virginia Journal of Science

VPI Eng. Exp. Sta. Ser. Bul. Virginia Polytechnic Institute, Engineering Experiment Station, Series Bulletin

W. U. Tech. Rev. Western Union Technical Review

Welding J. Welding Journal

Welding J. Res. Suppl. Welding Journal, Research Supplement

Welding Res. Welding Research (London)

Weltraumfahrt (Frankfurt am Main)

Western Av. Western Aviation

Westinghouse Engr. Westinghouse Engineer

Whites' Av. Whites' Aviation

Wireless Engr. Wireless Engineer

Wireless World

WMO Bul. World Meteorological Organization Bulletin

Z. für Elektrochemie. Zeitschrift für Elektrochemie (Halle, Germany)

Z. für Instrumenkunde. Zeitschrift für Instrumenkunde (Berlin)

Z. VDI. Zeitschrift des Vereins Deutscher Ingenieure (Berlin)

ZAMM. Zeitschrift für angewandte Mathematik und Mechanik (Berlin)

ZAMP. Zeitschrift für angewandte Mathematik und Physik (Zurich)

ZFW. Zeitschrift für Flugwissenschaften (Braunschweig)

Zurich Tech. U. Papers. Zurich Technological University, Papers

ZWB UM. Zentrale für Wissenschaftliches Berichtswesen ueber Luftfahrtsforschung, Untersuchungen und Mitteilungen

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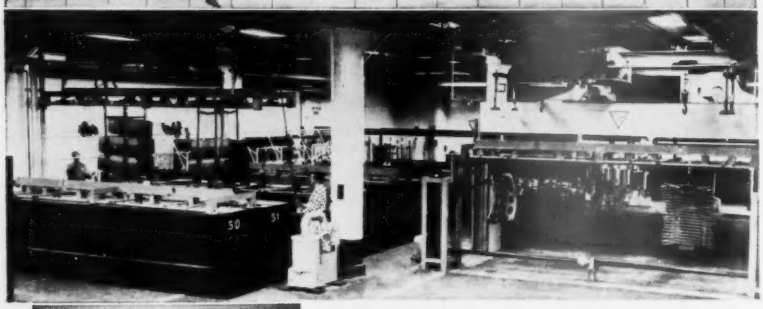

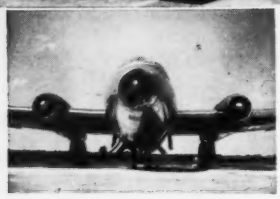

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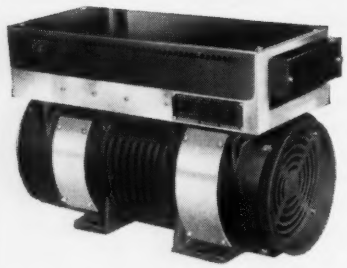

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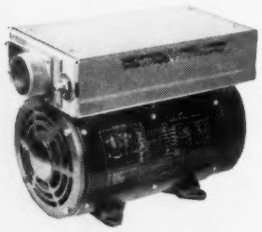

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Efficiency	55%
200% load	5 sec.
150% load	5 min.

WEIGHT: Approximately 62 pounds.

MAXIMUM OVER-ALL DIMENSIONS: 7¼" wide x 11¼" high x 17" long.

ALTITUDE	AMBIENT TEMP. RANGE
Sea Level	−55°C to +85°C
35,000 ft.	−55°C to +40°C
50,000 ft.	−55°C to +20°C

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Input DC	
Voltage Range	26 to 29
Current Range	24.1 to 21.6
Current at 27.5 volts	22.8
Output AC	**Three Phase**
Volts	115/200±4% (115±4%, single phase)
Amperes	1.25/.723 (2.17, single phase)
Volt-Amperes	250 (single phase, three phase, or single and three phase combined)
Frequency-cycles/sec.	400±10
Power Factor	0.8 lag to .95 lead
Watts at 0.8 PF lag	200
Efficiency	40%
200% load	5 sec.
150% load	5 min.

WEIGHT: Approximately 17 pounds.

MAXIMUM OVER-ALL DIMENSIONS: 5½" wide x 8" high x 12" long.

ALTITUDE	AMBIENT TEMP. RANGE
Sea Level	−55°C to +85°C
50,000 ft.	−55°C to −10°C
65,000 ft.	−55°C to −10°C

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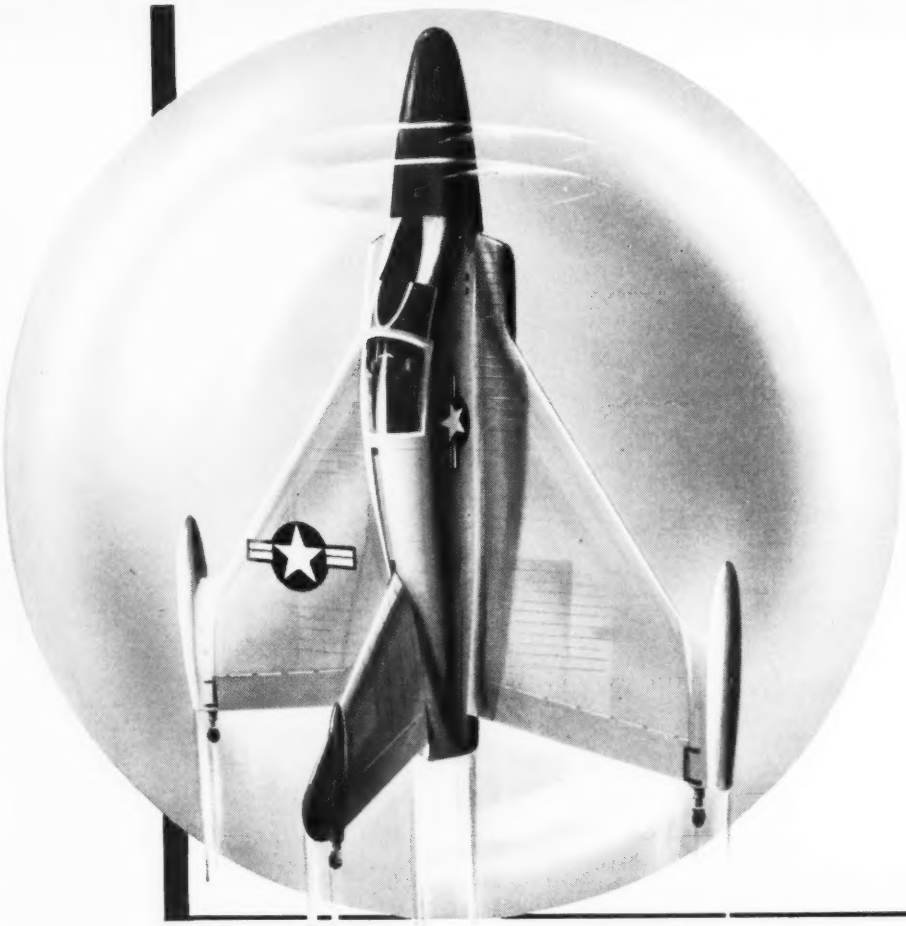

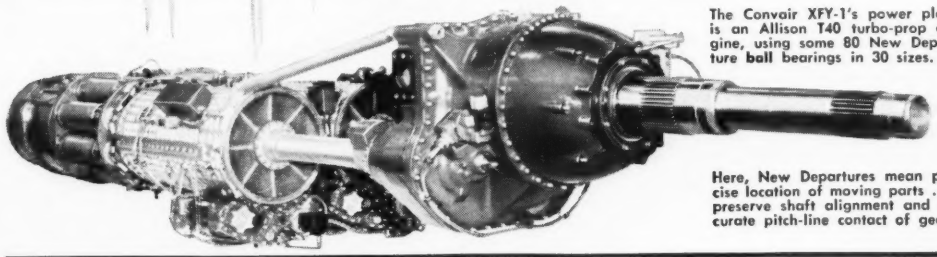

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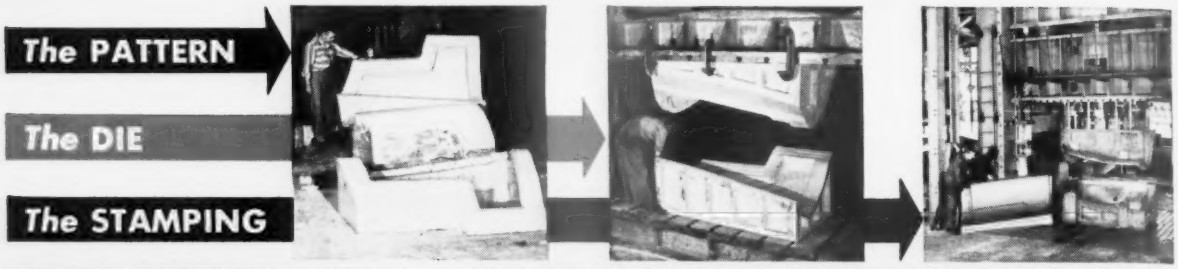

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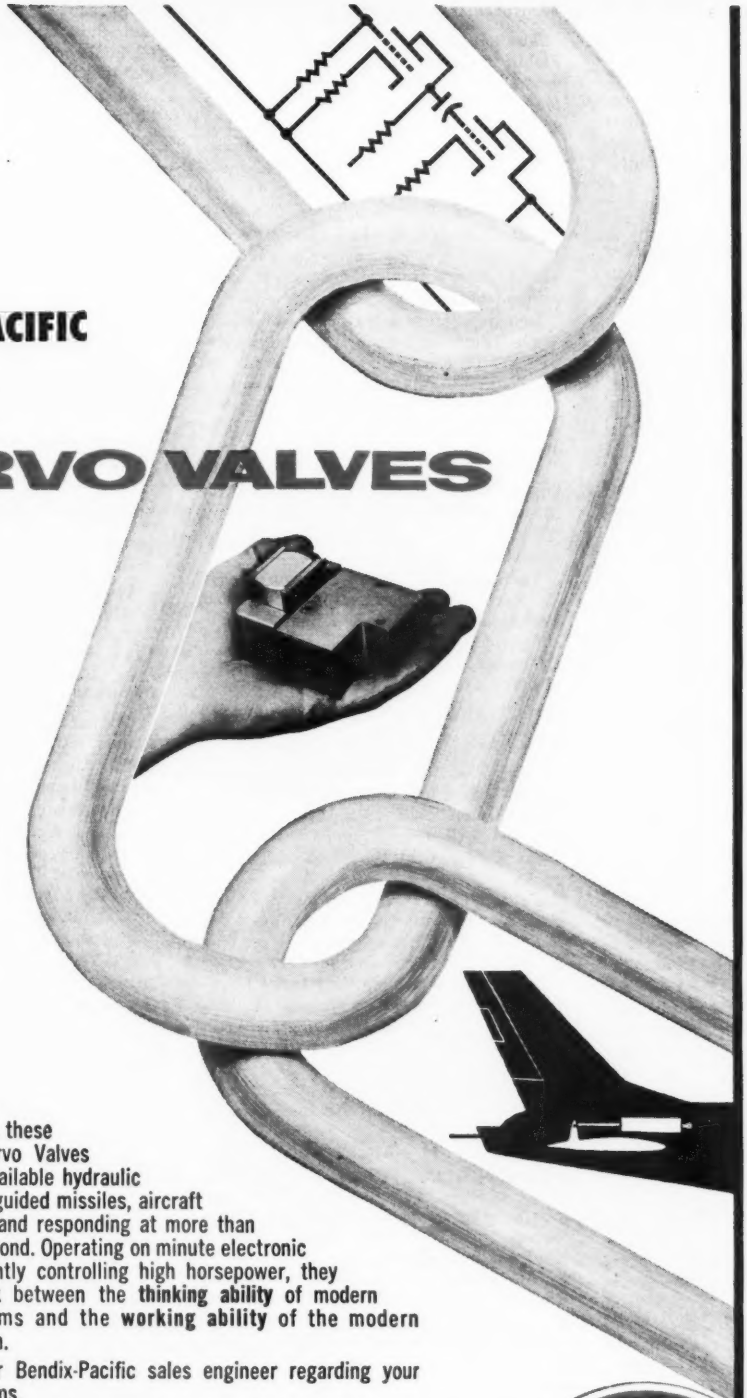

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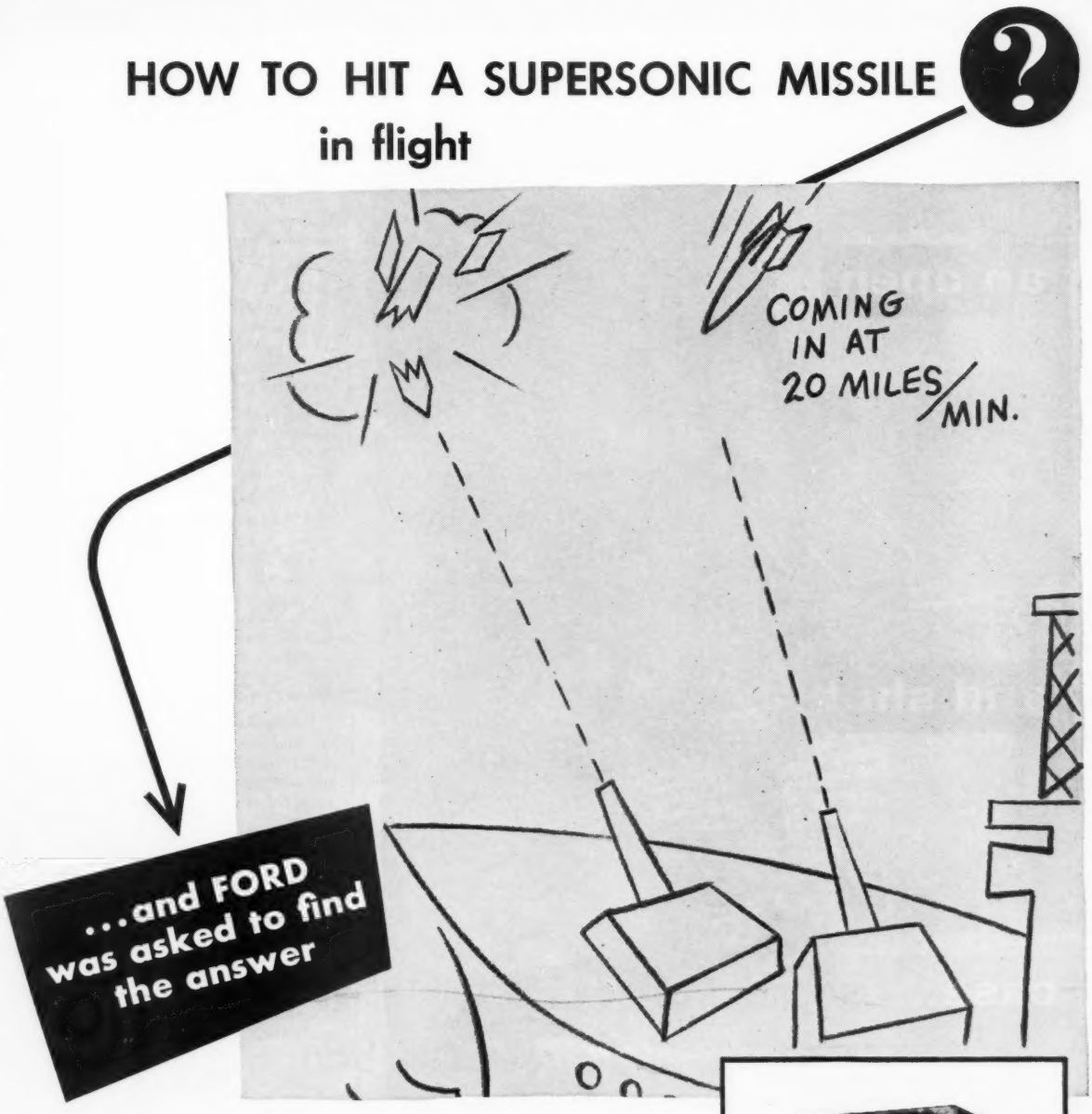

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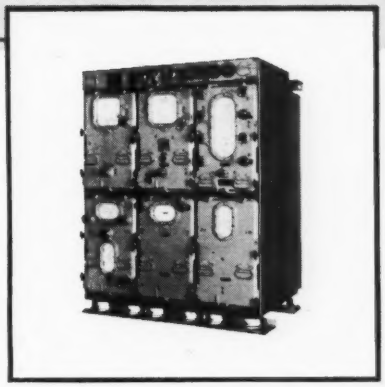

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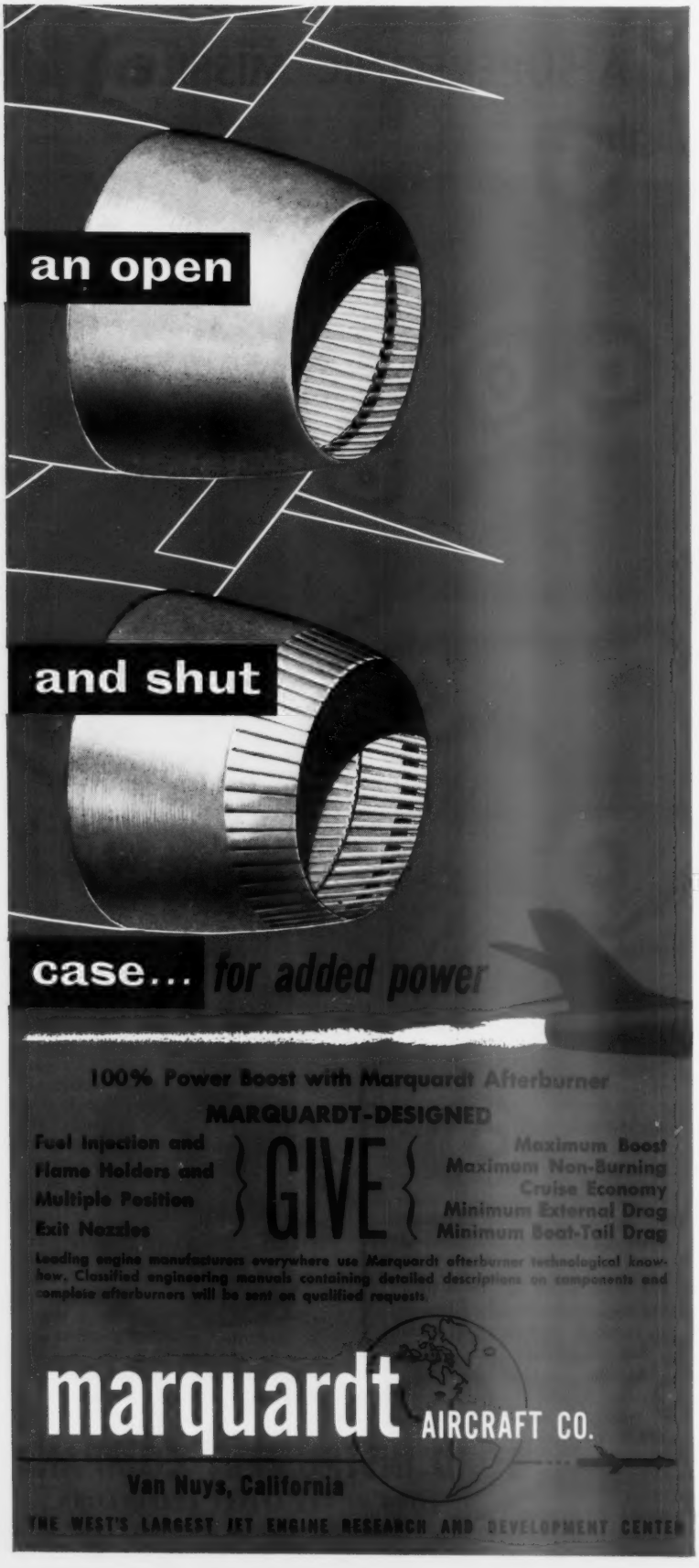
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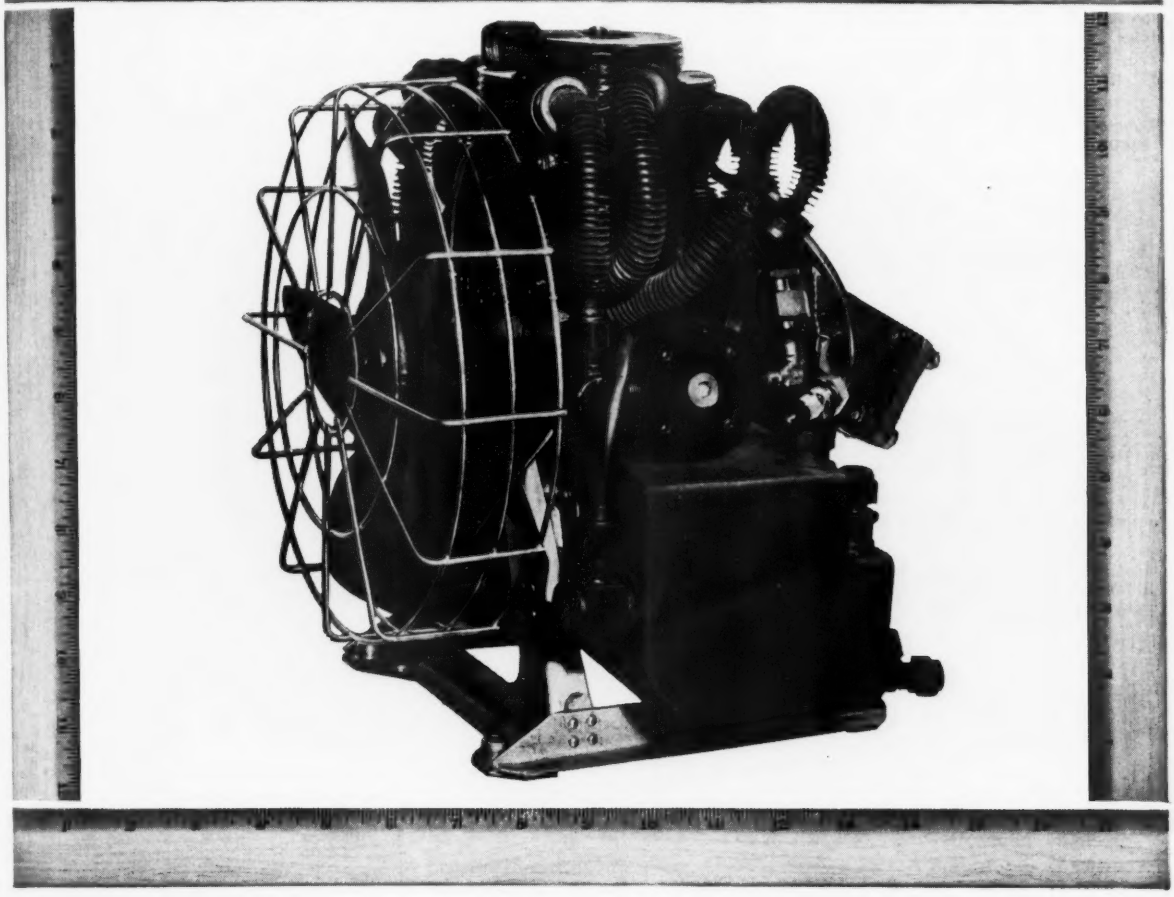

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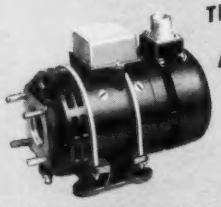

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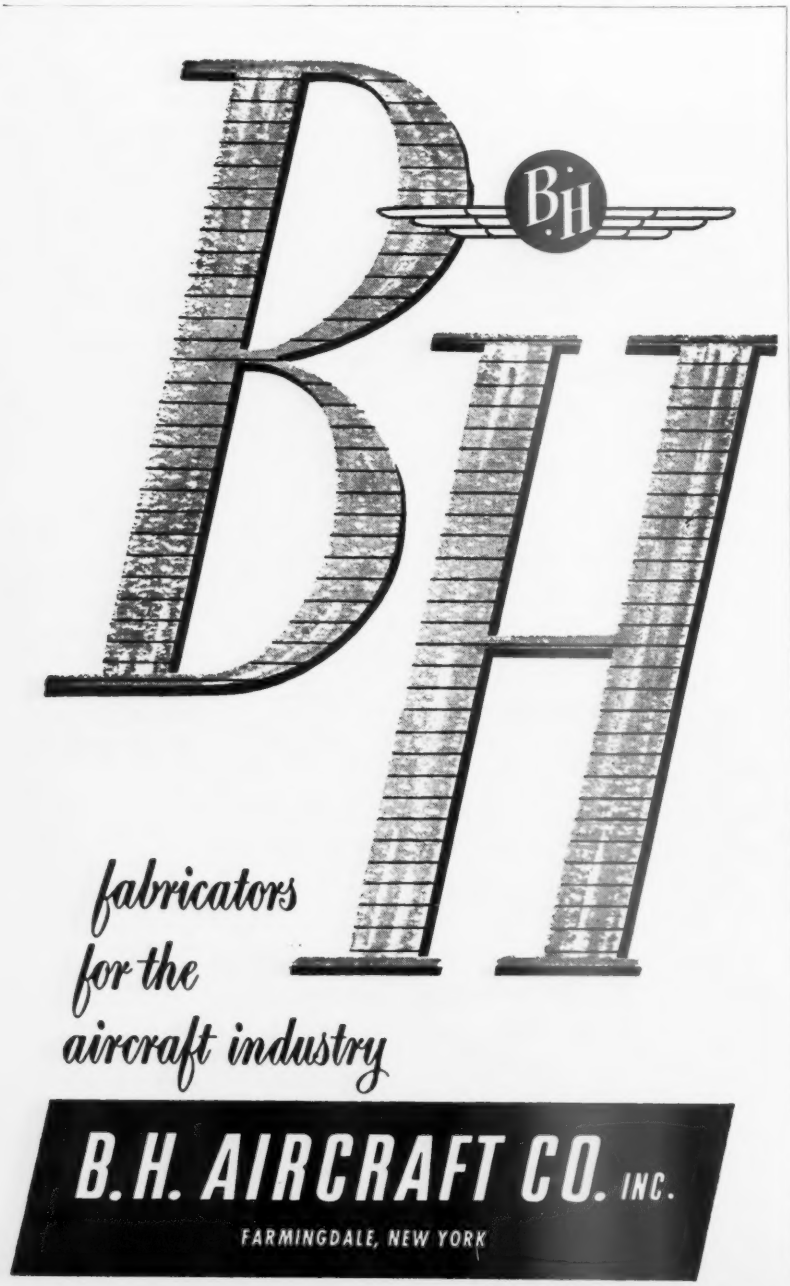

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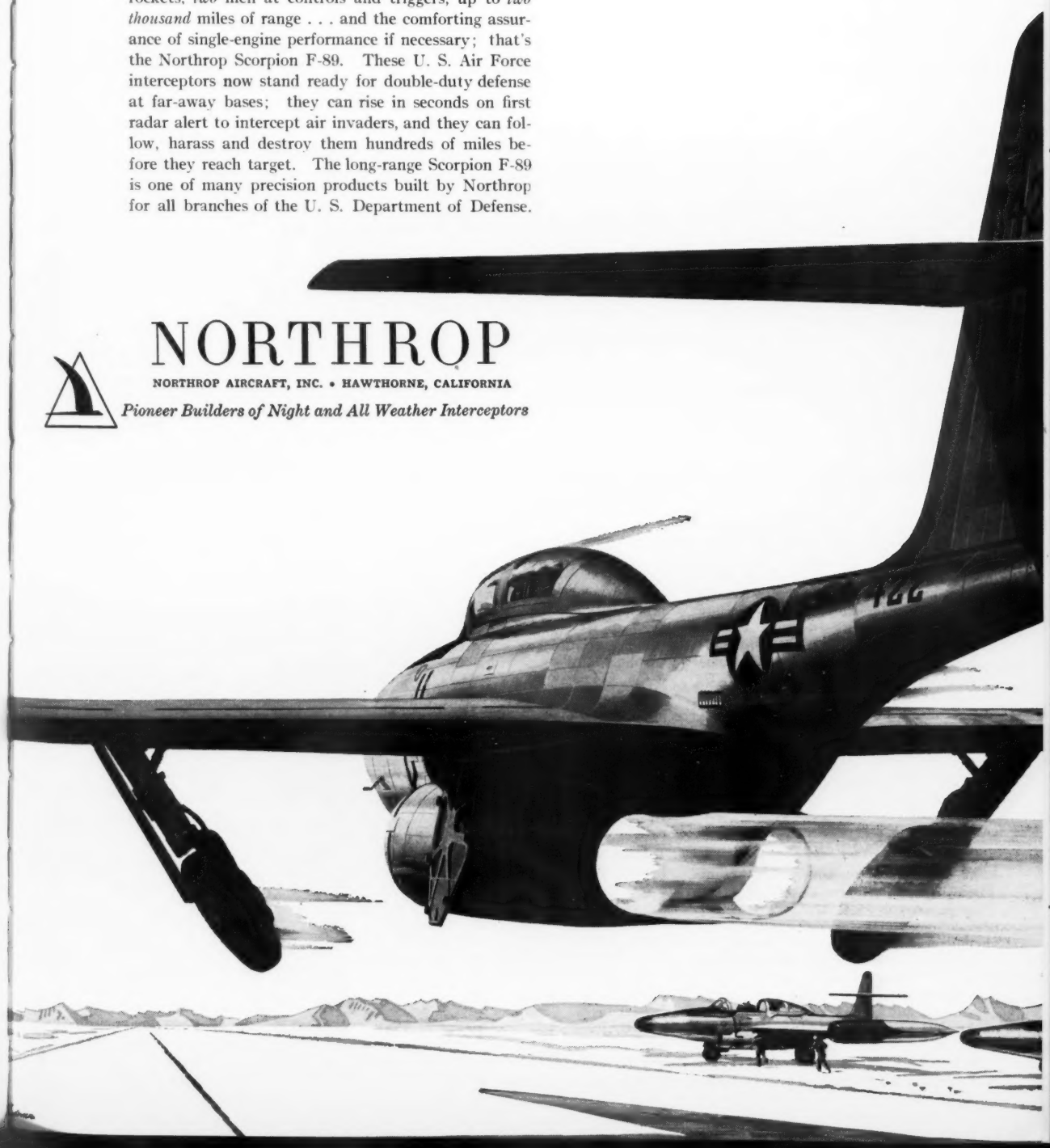

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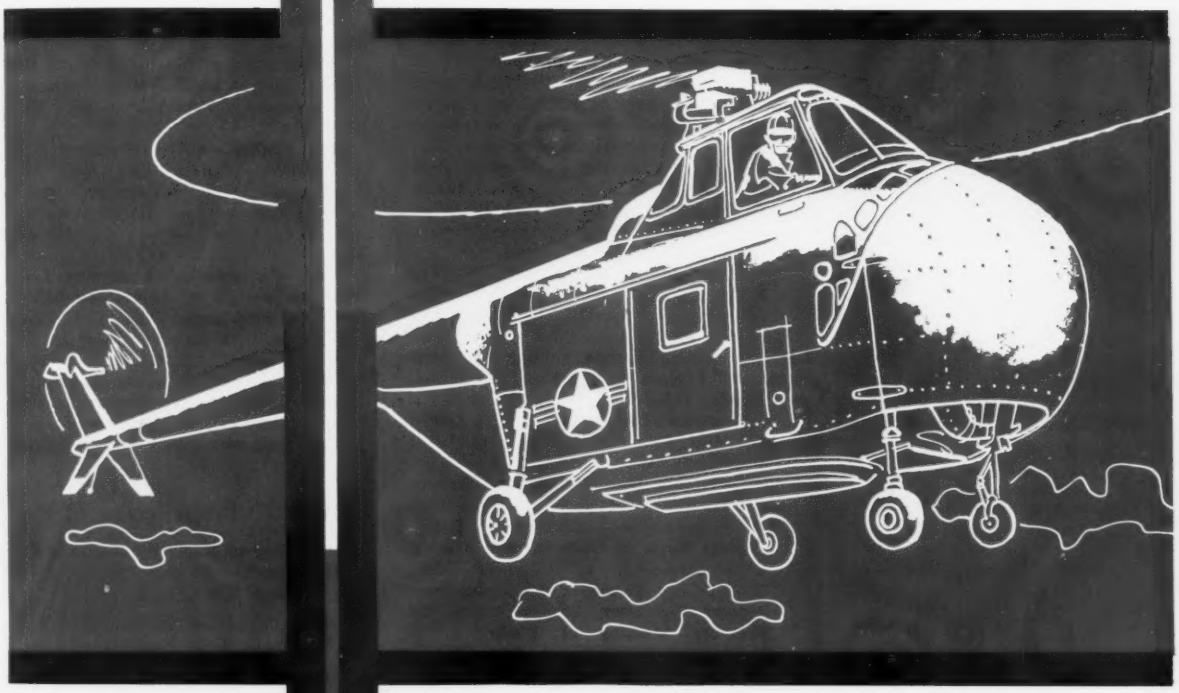

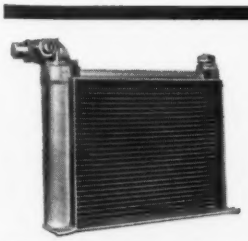

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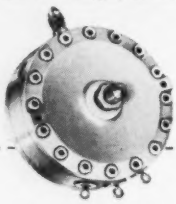

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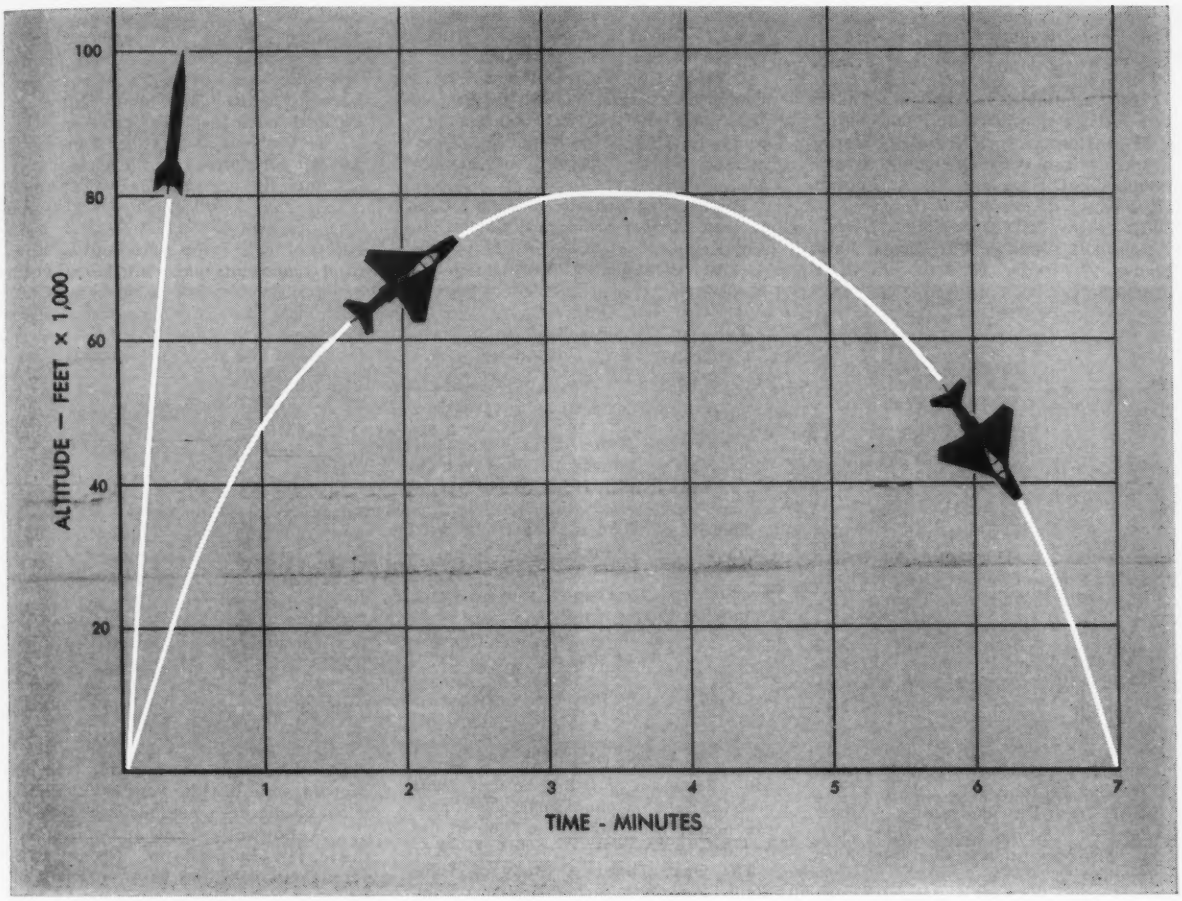

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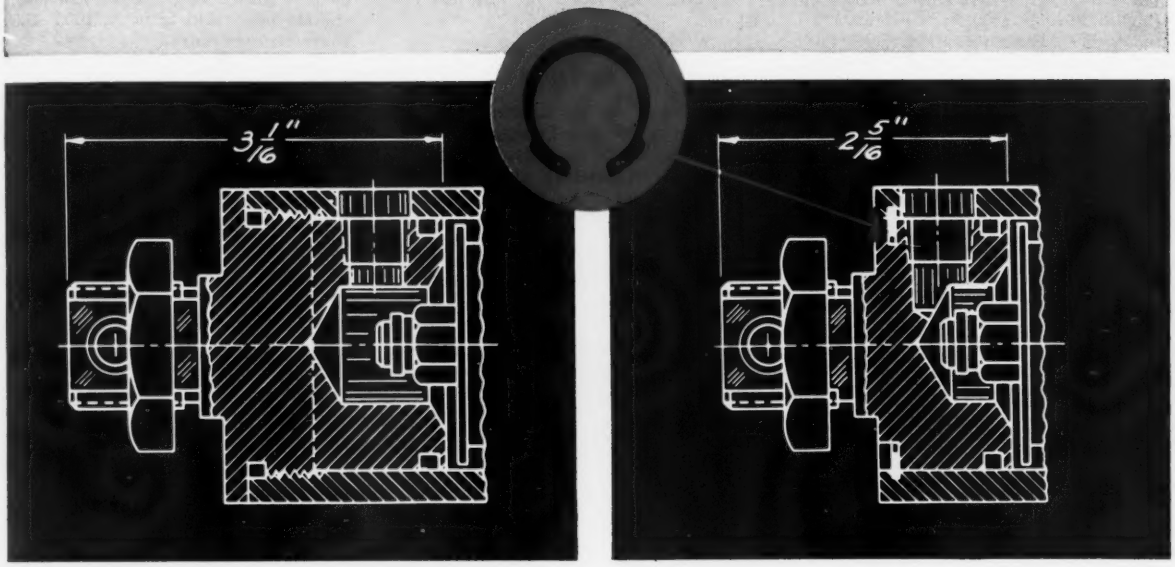

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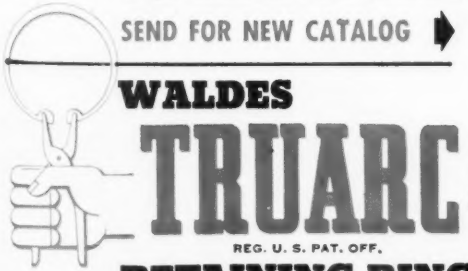

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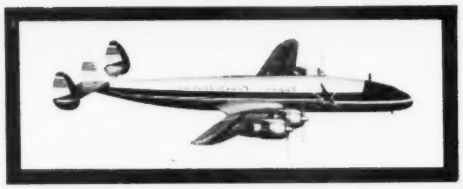

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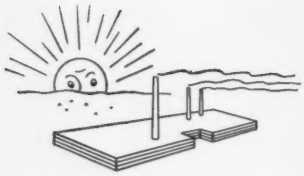

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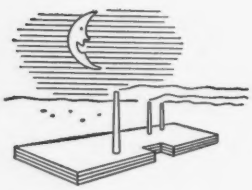

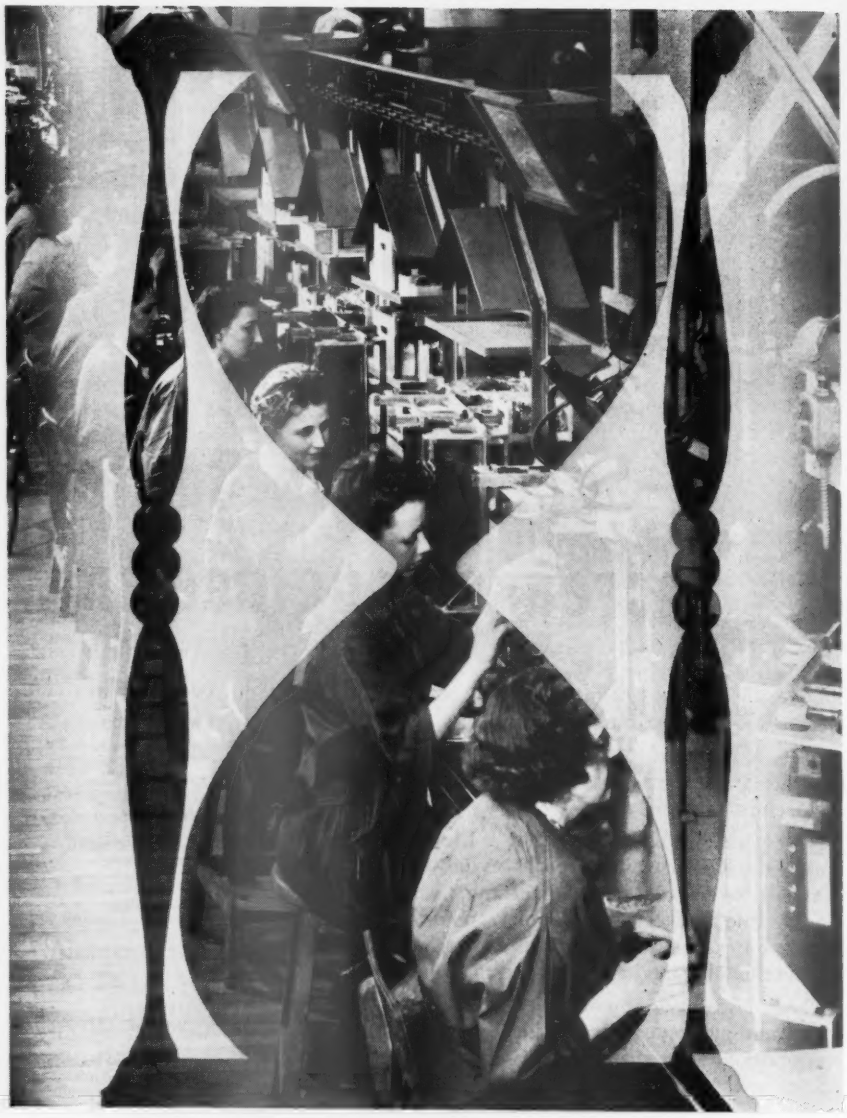

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Aeronautical Reviews — BOOKS

Principles of Aerodynamics

By Daniel O. Dommasch. New York, Pitman Publishing Corporation, 1953. 389 pp., figs. $7.50

Professor Dommasch states in the preface of his new book: "It is impracticable for the individual to keep pace with the specialized results which are appearing, but is essential that he understand the principles and procedures from which these results are developed. Principles and procedures are not nearly so specialized as their results and it is possible to study and understand most of them without straining one's capability beyond reasonable limits. The fundamental physical laws are few in number, may be precisely set forth, and normally, may be understood with little difficulty." That is a fair statement of the situation, if one does not quibble over the precise meaning of the last two words.

Professor Dommasch has demonstrated that it is possible to explain most of the basic aerodynamic theory without going too deeply into rigorous mathematics. The explanations are clear and properly complete rather than concise. The author knows from experience the points that a student finds difficult. These points have been given special treatment. The general level of the treatment is excellent.

Principles of Aerodynamics is intended to be used as a textbook in theoretical aerodynamics and to cover a lot of ground in the process. That puts both the author and the reviewer on the spot. It is much easier to write or to review a specialized text where the limitation in scope tends to emphasize the real contribution. In this case, the book appears well adapted to serve as an intermediate text. For a book of this size (389 pages) the ground covered is really surprising. Most of the basic theory in both incompressible and compressible flow has been covered, at least to the point where the student can understand the logic and mathematics involved. There are advantages and disadvantages in such a treatment. The advantages are concerned with the ability to set up a unit course with a single text. The disadvantages are due to the necessity for a definite limitation on the detail that can be handled. The general applicability of such a text depends therefore on how well it can be fitted into the educational pattern of a particular school. Essentially this is a matter of emphasis. *Principles of Aerodynamics* is concerned more with the understanding of the basic material than with delving into mathematical detail. The average engineer, and perhaps the average undergraduate student, would prefer to have it that way. However, this runs counter to a strong trend and is a subject that can evoke much controversy.

Although *Principles of Aerodynamics* is a textbook, it will have more than passing interest to aeronautical engineers as a convenient, easily understood reference work. The aeronautical engineer often needs such help these days.

CAPT. WALTER S. DIEHL
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Book Notes

ELECTRIC EQUIPMENT

D.C. Power Systems for Aircraft. R. H. Kaufmann and H. J. Finson. New York, John Wiley & Sons, Inc., 1952. 202 pp., illus. diagrs., figs. $5.00.

The authors study aircraft power systems from the point of view of how the individual electrical devices work together to make up the complex power system. They explain the practices generally used by engineers in the field, analyze their worth on the basis of performance data obtained in actual flight tests, and express them as general principles that the reader can apply to specific design and operation problems. Their work is based both on theoretic analysis and on flight and laboratory tests made by the authors and their associates at General Electric and at the Air Force laboratories at Wright Field. The authors use a minimum of mathematics in developing operating theory. They rely on performance data from actual flight tests to discover and point out the basic performance qualities of d.c. power systems. They interpret and extend the data through the use of logic, and express the final relationships in simple mathematics and in the form of easily interpreted curves and charts. References are given at the ends of chapters.

ELECTRONICS

Active Networks. Vincent C. Rideout. New York, Prentice-Hall, Inc., 1954. 485 pp., diagrs., figs. $10.65.

The treatment in this work is intended to cover not only vacuum-tube networks, but also the fundamentals of all networks capable of amplification. The chief emphasis is on vacuum-tube circuits as applied to communication and control engineering, but the transistor is also dealt with in considerable detail, and sections have been included on thyratrons, magnetic amplifiers, and the position-control servomechanism. Much of the material in the text has been used in mimeographed form in a course for senior electrical engineering students given at the University of Wisconsin during the past several years.

Essentials of Microwaves. Robert B. Muchmore. New York, John Wiley & Sons, Inc., 1952. 236 pp., illus., diagrs. figs. $4.50.

This book, written by a member of the technical staff in the Research and Development Laboratories, Hughes Aircraft Company, presents the physical principles that underlie the operation of all microwave devices. The author stresses the physical picture and presents concepts in words rather than in mathematics. In accordance with this aim, over 200 illustrations have been employed.

Antennas: Theory and Practice. Sergei A. Schelkunoff and Harald T. Friis. New York, John Wiley & Sons, Inc., 1952. 639 pp., diagrs., figs. $10.

This book deals with antennas of various types in various frequency ranges, offering a thorough treatment of the basic ideas and techniques necessary to understand antenna behavior. Combining a thorough discussion of antenna principles and the theory of radiation with practical applications, it stresses physical ideas and pictures as well as methods of quantitative analysis. It has been written primarily for students and practitioners of radio engineering, but no specialized engineering background is required for understanding it. The book should be intelligible to students of applied mathematics and physics and to mathematical consultants in industry.

Advanced Antenna Theory. Sergei A. Schelkunoff. New York, John Wiley & Sons, Inc., 1952. 194 pp., figs. $6.50.

Advanced Antenna Theory presents in rigorous fashion the theory behind antenna behavior and

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broad-band antenna design and serves as a review of current trends in antenna research and development. Dr. Schelkunoff divides his material into six sections: Spherical Waves, Mode Theory of Antennas, Spheroidal Antennas, Integral Equations, Cylindrical Antennas, and Natural Oscillations. This volume contains much hitherto unpublished material. Stressing physical interpretations of the mathematical methods employed, the author emphasizes the method based on spherical wave functions because it is applicable to many problems and has a particularly simple physical significance.

HISTORY

Flight; A Pictorial History of Aviation. Baldwin H. Ward, Editor. Los Angeles, Year, Inc., 1953. 192 pp., illus. $10. (IAS members may purchase copies from the publishers at a special price of $5.95 each, plus 25¢ postage.)

This pictorial history of aviation, published during the 50th anniversary year of powered flight, contains 1,300 pictures and over 75,000 words of caption and text. In the gathering of illustrations and information for this work, many private and public collections of photographs, documents, and source material were searched, and many authorities were consulted. The book is divided into eight sections, each covering an important period of development, as follows: Balloons and Gliders; Wright Brothers' Era (1903–1913); First World War (1914–1918); Courageous Twenties (1919–1929); Age of Commercial Aviation (1930–1938); World War II (1939–1945); Post-War Era; and The Future. Each section is prefaced by statements from aviation pioneers and leaders. Added reference value is provided by a detailed index and a compilation of the world's principal aeronautical collections and libraries.

MATERIALS

Silicones and their Uses. Rob Roy McGregor. New York, McGraw-Hill Book Company, 1954. 285 pp., illus., diagrs., figs. $6.00.

For engineers, designers, and all who use silicones, this volume provides a correlated source of the available information on properties, preparation, and applications, treated as nontechnically as possible for maximum understanding and usefulness. Representative industries and the uses they are making of silicones are tabulated, and techniques of application are shown. The author is Administrative Fellow, Mellon Institute.

Metal Data. S. L. Hoyt. 2nd Ed. New York, Reinhold Publishing Corporation, 1952. 518 pp., illus., diagrs., figs. $10.

This new edition of the author's *Metals and Alloys Data Book* not only includes the most recent information available, but offers new data on such topics as hardenability of H-steels, recently developed super alloys for high-temperature stress members, and other new alloys. The material is offered in tabular form with a minimum of descriptive text. Nearly 700 tables and graphs are presented.

MATHEMATICS

Theory of Functions of Real Variables. Henry P. Thielman. New York, Prentice-Hall, Inc., 1953. 203 pp., figs. $6.65.

The object of this course is to familiarize the reader with the fundamental concepts and methods and to introduce him to the postulational approach to various mathematical theories. Problems are included in the body of the book wherever they arise naturally. Special emphasis has been placed on existence proofs. The topics considered are those that are generally included in standard mathematics courses for first-year graduate students and advanced undergraduates.

Introduction to the Theory of Finite Groups. Walter Ledermann. 2nd Rev. Ed. New York, Interscience Publishers, Inc., 1953. 160 pp. $1.55.

The purpose of this book is to introduce the reader to some of the fundamental concepts and results of the theory of finite groups. By limiting

the range of topics the exposition has been kept on an elementary level so that the book will meet the needs of students who have had no previous acquaintance with the subject. Special attention is paid to the construction and study of particular groups, including those that arise in geometry and arithmetic; these serve to illustrate the more abstract ideas of the general theory. Permutation groups are discussed in some detail but no mention is made of group characters.

METEOROLOGY

Physical Meteorology. John C. Johnson. New York, The Technology Press of the Massachusetts Institute of Technology and John Wiley & Sons, Inc., 1954. 393 pp., diagrs., figs. $7.50.

The book is designed to meet the needs of research workers in the fields in which the atmosphere plays a significant role. At the same time, it is planned to fill the requirements of professional meteorological courses at the college level. Extensive bibliographies cover original sources, important surveys, and recent additions to the literature. The author is Research Associate, Research Laboratory of Physical Electronics, Tufts College.

Contents: (1) Atmospheric Refraction. (2) Scattering in the Atmosphere. (3) Theory of Atmospheric Visibility. (4) Radiation Processes in the Earth's Atmosphere. (5) Radiation Studies and the Heat Budget of the Earth. (6) Refraction and Diffraction by Atmospheric Suspensoids, Atmospheric Optics. (7) The Physical Conditions Attending the Formation of Cloud Particles. (8) Natural and Artificially Stimulated Precipitation, Icing of Aircraft, and Radar Meteorology. (9) Atmospheric Electricity. (10) The Ionosphere and the Ozonosphere. (11) The Temperature, Density, Pressure, and Humidity of the Upper Atmosphere. Appendix. Index.

PRODUCTION

Welding Engineering. Boniface E. Rossi. New York, McGraw-Hill Book Company, Inc., 1954. 756 pp., illus., diagrs., figs. $8.00.

The book aims to familiarize the student or beginner with fundamental facts concerning welding; to give those in the welding field a wider understanding of the process; and to provide a useful source of reference for the draftsman, designer, engineer, researcher, executive, and anyone else seeking information on welding and its applications. Treatment is technical and practical. Material in this text has been tried in lecture form during the past five years by the author in his welding course at the Industries Training School, Stevens Institute of Technology.

Welding Processes and Procedures. Joe L. Morris. New York, Prentice-Hall, Inc., 1954. 248 pp., illus., diagrs., figs. $5.00.

The author has prepared this book for those groups attending colleges that offer brief courses in welding, and for technical institutions and the more advanced vocational schools. The arrangement relating to the more important welding processes is as follows: (1) history, (2) description, (3) details of use, (4) applications and limitations. The practicing engineer and the industrial worker will also find the book useful because of its manner of presenting welding processes and procedures.

STRUCTURES

Theory and Experiments on the Elastic Overall Instability of Flat Sandwich Plates (Doctoral Dissertation). F. J. Plantema. Delft, Netherlands, Technische Hogeschool, May, 1952. 67 pp., illus., diagrs., figs.

In the first part of this thesis a method is discussed which was developed from 1948 onwards and has been applied with success in a number of cases. To verify the computed results experimentally, a program of compression tests was carried out at the Nationaal Luchtvaartlaboratorium, Amsterdam. These tests are dealt with in the second part, where also the theoretical and experimental results are compared and the probable explanation of the discrepancies is discussed

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Personnel Opportunities

This section is for the use of individual members of the Institute seeking new connections and organizations offering employment to Aeronautical specialists. Any member or organization may have requirements listed without charge by writing to the Secretary of the Institute.

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Aircraft Accident Investigator—To teach accident prevention and investigation in contract school for Air Force Pilots. Possibility of expanding into program for industry. Desire A.E. degree, flying experience, and investigation experience. Salary $8,000–$9,000. Flying Safety Training School, University of Southern California, Los Angeles 7, Calif.

Academic Positions—The University of Toledo has several openings in the Department of Engineering Mechanics, with ranks from instructor to associate professor or professor. Applicants should have advanced degree(s) and, preferably, they should have teaching and industrial experience as well. For the higher ranking appointment a thorough background in modern experimental techniques applied to structural analysis, elasticity and plasticity is required. Duties include teaching of undergraduate and graduate courses, and the development of laboratories in strength of materials, fluid mechanics and dynamics. Applicants should write to Professor R. M. Rosenberg, Department of Engineering Mechanics, University of Toledo, Toledo 6, Ohio, and they should state their qualifications in the first communication.

Aeronautical Research Personnel—Cornell Aeronautical Laboratory, Inc., an affiliate of Cornell University, has the following research and development opportunities: **Wind-Tunnel Operations**—To assist in the planning of test programs and instrumentation for model tests and airflow calibrations in our 8½- by 12-ft. variable-density tunnel. **Flight Research**—To assist in the analysis and project execution of dynamic stability and control programs utilizing full-scale aircraft. Must have a good grasp of rigid body dynamics. **Aeroelasticity**—Analytical and experimental research in aircraft flutter phenomena. Large scale wind-tunnel models are designed and tested to provide data for comparison with existing aeroelastic theories. **Propulsion**—Must be well versed in both theory and practical applications. Would join a composite design group where continual studies of advanced-type aircraft and missiles are undertaken. Address inquiries to W. S. Diefenbach, Employment Manager, Cornell Aeronautical Laboratory, Inc., Buffalo 21, New York.

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591. Aeronautical or Mechanical Engineer—Either new graduate or preferably one with several years' experience in aircraft structures design who can work on Assistant Project Engineer level with very little supervision, make own design schematics, layouts, drawings, and monitor work of other specialists or technicians in prominent small research and development organization. Unlimited opportunities for individual demonstrating initiative, ability, and accomplishment. Location: Midwest. Salary open.

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The number preceding the notice represents the Box Number of the Institute of the Aeronautical Sciences to which inquiries should be addressed.

Available

601. Advertising & Public Relations Manager—B.S. in Engrg./Business Admin., MBA in Marketing. Age 34. Ten years' progressive experience in all phases of industrial promotions: program planning; budgeting and administration; agency and media liaison; space and promotional copy planning, writing, and editing; pamphlets and brochures; and technical publicity. Press, industry, and government relations. Licensed pilot, mechanic, and radio operator with background in aviation equipment, radio and electronics, and air transport. Desires position offering greater responsibilities and opportunity for advancement.

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592. Plant Manager—Administrative Engineer—Arts Associate, B.S. in General Engineering, M.S. in Aeronautical Engineering. Registered Professional Engineer, 6 years' experience in research, development, and quality control of all types of aircraft propulsion systems plus over 4 years' experience as consultant on all types of management problems. Desires challenging management position in aircraft or associated industry.

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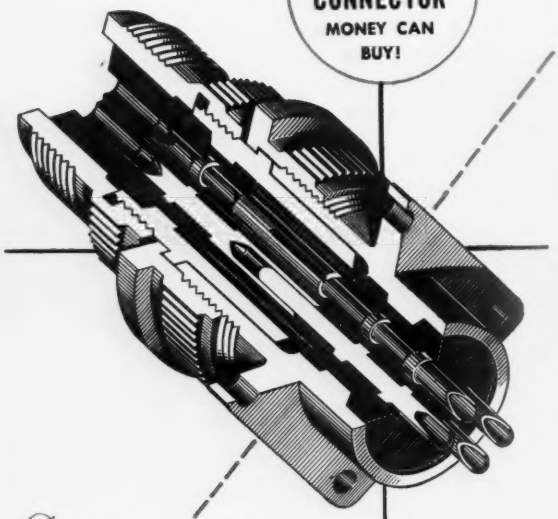

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★ *Specifications and further information on the aircraft products of these companies will be found in the* **1954 AERONAUTICAL ENGINEERING CATALOG**

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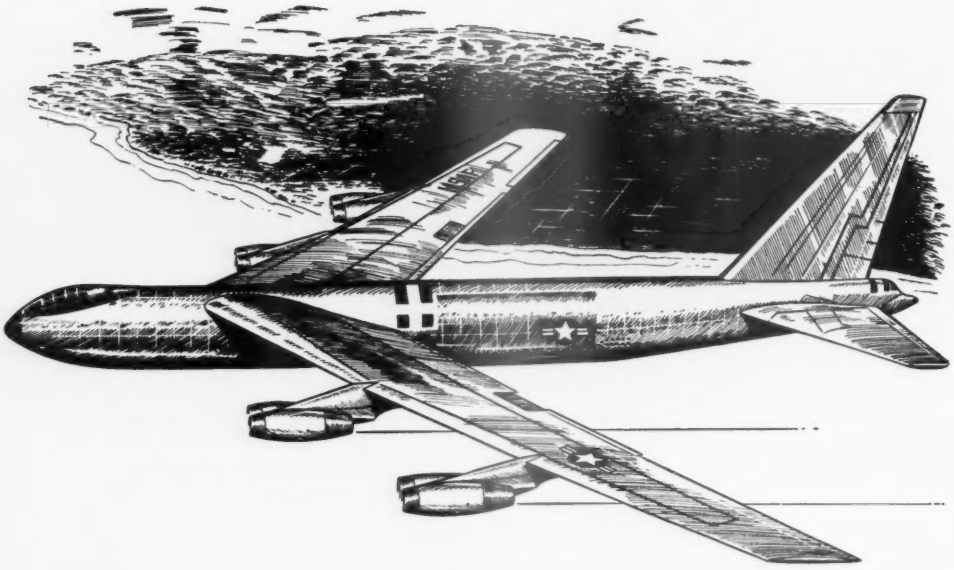
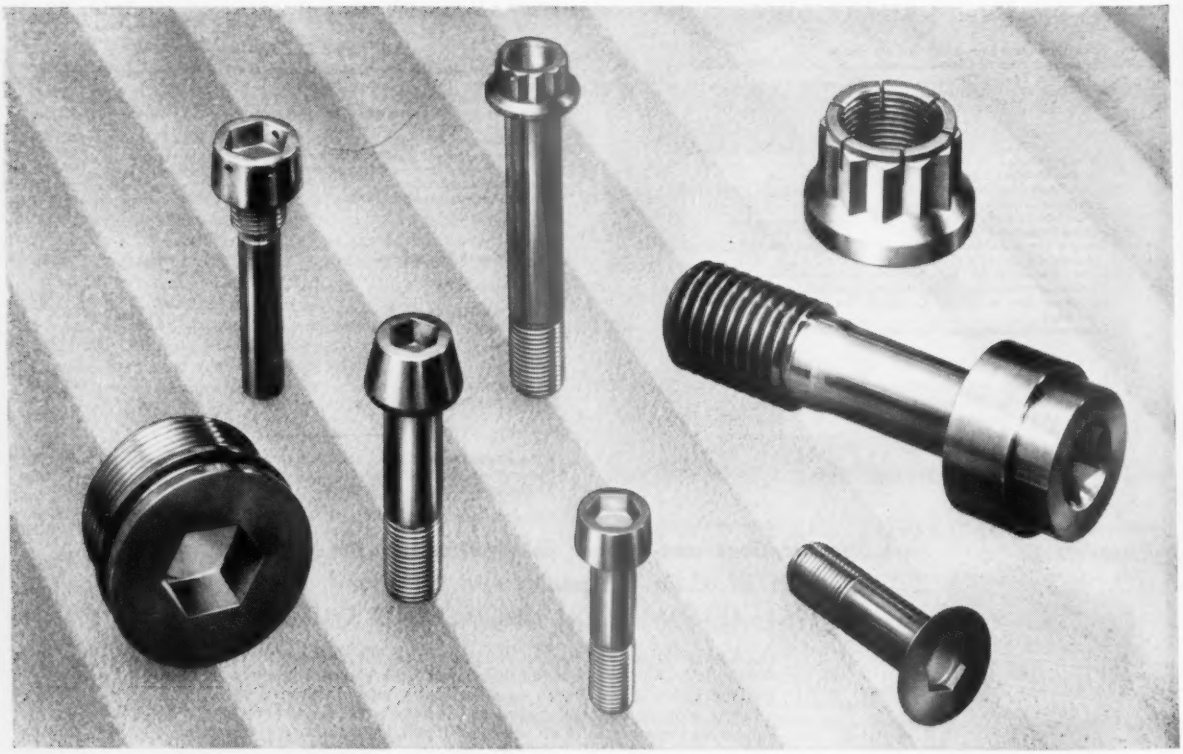
Boeing B-52 Stratofortress uses SPS Precision Fasteners





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"Alcoa Impact Fact Book." Sixteen pages, describes aluminum impact extrusion process. **Aluminum Co. of America, 724 Alcoa Bldg., Pittsburgh 19, Pa.**

"Research at Alcoa." Fifty-four-page booklet, describes company's facilities and equipment. **Aluminum Co. of America, 726 Alcoa Bldg., Pittsburgh 19, Pa.**

Seamless Tubing Steel. Designed for conditions involving high stresses and temperatures. **Babcock & Wilcox Co., Tubular Products Div., 161 E. 42nd St., New York, N.Y.**

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Silastic Facts 9-334. A reference guide to 30 of the most popular stocks and pastes. **Dow Corning Corp., Midland, Mich.**

FF-91 Epoxy-Type Copper-Clad Laminated Plastic. For printed circuit applications. **The Formica Co., 4614 Spring Grove Ave., Cincinnati 32, Ohio.**

Plast-Iron B-212, Reduced-Oxide Iron Powder. Technical data sheets Nos. 28A & 28B give chemical and physical characteristics. **The National Radiator Co., Johnstown, Pa.**

No. 155 Nonstaining Elastic Sealing Tape. For sealing metal seams and joints, glass and rubber channels, and as an antisqueak material. **Presstite Engineering Co., 3798 Chouteau Ave., St. Louis 10, Mo.**

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Rubber O-Ring Seals. Sixteen-page brochure describes production and applications. **Minnesota Rubber & Gasket Co., Dept. KP, 3630 Wooddale Ave., Minneapolis 16, Minn.**

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Vibration and Shock Mounts for Electronic Equipment. Four-page bulletin No. 800, describes mounting systems for missile and jet-aircraft applications. **Robinson Aviation, Inc., Airborne Div., Teterboro, N.J.**

Bearing Application Evaluation Chart. This chart lists 17 basic performance and application elements to be considered in selecting bearings. **Thomson Industries, Inc., Engineering Dept., Manhasset, N.Y.**

Hydraulic O-Rings & Back-Up Rings. Four-page descriptive catalog No. OB-1152. **U.S. Gasket Co., Camden 1, N.J.**

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Aircraft Accessories for Use with Flexible Shafts. Four-page bulletin No. 5403, describes screw jacks, pressure bulkhead fittings, and flexible adapters. **S.S.White Industrial Div., 10 E. 40th St., New York 17, N.Y.**

"Riv-O-Seal" Method of Sealing Flush Rivets & Screws. Eliminates the need for sealing pastes and provides a seal against gases or fluids at high and low pressures. **Franklin C. Wolfe Co., 3644 Eastham Dr., Culver City, Calif.**

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Microwave Balanced Mixer Design. Six-page technical bulletin No. T-2600. **Airtron, Inc., 1103 W. Elizabeth Ave., Linden, N.J.**

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Germanium Diodes. "Red Dot" series for equipment operating at a high ambient temperature. Bulletin No. ER-191. **International Rectifier Corp., 1521 E. Grand Ave., El Segundo, Calif.**

Type 2063-01 Lightweight Magnetic Amplifier. Designed for use in meteorological sensing systems, in aircraft, and in navigational, gun-fire, and other precision automatic controls. **Kollsman Instrument Corp., 80-08 45th Ave., Elmhurst, N.Y.**

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Modular Mounting Units. For semiautomatic assembly of electronic equipment, using standard components. **Mycalex Corp. of America, Clifton Blvd., Clifton, N.J.**

Printed Circuit Tube Socket. For general use in printed circuitry. **Mycalex Tube Socket Corp., Clifton Blvd., Clifton, N.J.**

Helium-Filled Switch "Button." Consists of a set of movable contacts in an accordion-like diaphragm enclosure filled with helium gas under pressure to reduce arcing and pitting. **Slater Electric & Mfg. Co., Inc., Woodside, N.Y.**

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Series HVT Miniature, Hermetic-Sealed Rectangular Connector. For electronic apparatus where sealed units are used. **Viking Electric, 1061 Ingraham St., Los Angeles 17, Calif.**

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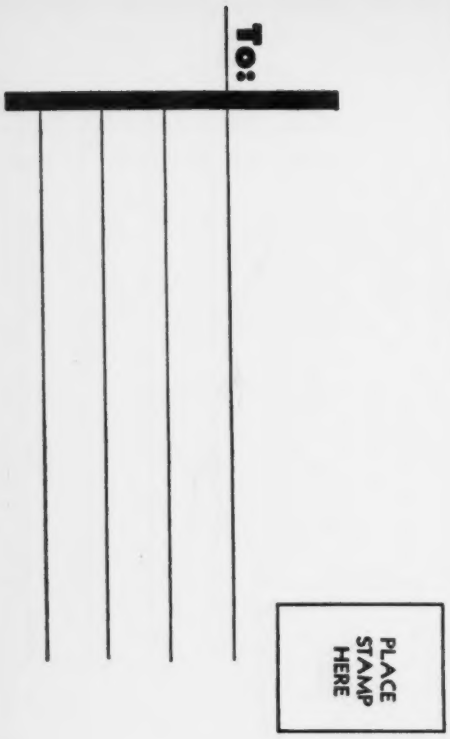

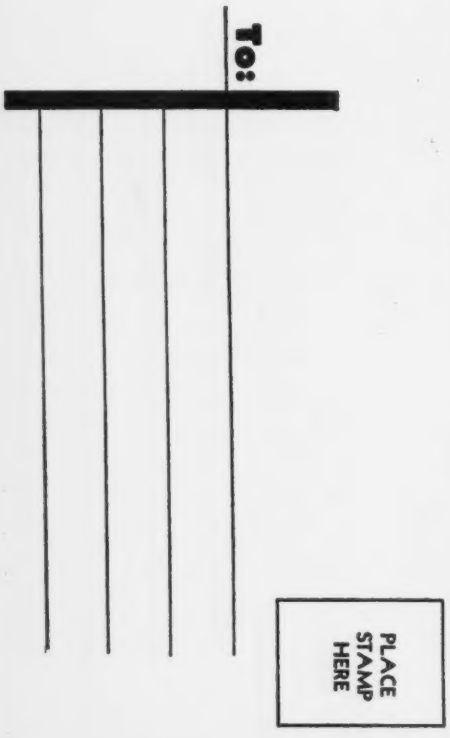

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Precision Strobe Monitoring System. Developed for the Genisco rate-of-turn table to provide an accurate and widely variable rate-of-turn standard for gyro development and testing. **Genisco, Inc., 2233 Federal Ave., Los Angeles 64, Calif.**

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Thermoelectric Pyrometers. Descriptive bulletin No. 4371 entitled, "Temperature Indication." **Illinois Testing Laboratories, Inc., 420 N. La Salle St., Chicago 10, Ill.**

Trace-O-Meter. Designed so that one man instead of two can trace electrical lines and cable circuits. **Jackson Electrical Instrument Co., 20-38 S. Patterson Blvd., Dayton 2, Ohio.**

Electronic Information Storage System. Four-page pamphlet describes technical functions of this "Magnetic Library System," and outlines its application in various operations. **Logistics Research, Inc., 141 S. Pacific Ave., Redondo Beach, Calif.**

Cable Tensiometers. Descriptive bulletin. **Pacific Scientific Co., 1430 Grande Vista Ave., Los Angeles 23, Calif.**

Pyro Micro-Optical Pyrometer. For precision temperature measurements over 700°C. **Pyrometer Instrument Co., Inc., Bergenfield, N.J.**

Automatic Impact Tester. For determining the breaking point of gear teeth and studying the dynamic properties of parts subject to shock. **Tinius Olsen Testing Machine Co., 1004 Easton Rd., Willow Grove, Pa.**

Series 300 Portable Potentiometer. Improves flexibility for checking and calibrating temperature measurement and control instruments. **Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.**

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Electro-Mechanical Actuators. Catalog. **Airborne Accessories Corp., Hillside 5, N.J.** *See page 98*

Aircraft Bolts and Fasteners. Catalog. **Aircraft Bolt Corp., 701 W. Garvey Blvd., El Monte, Calif.** *See page 78*

"AN" Connector Assemblies. AN9 bulletin. **Cannon Electric Co., 3209 Humboldt St., Los Angeles 31, Calif.** *See page 95*

Facilities for Military Production. Booklet entitled, "Right and On Time." **Crosley Div., Avco Mfg. Corp., Cincinnati 15, Ohio** *See page 101*

Aircraft Gearing. Facilities Brochure. **Indiana Gear Works, Inc., Indianapolis 7, Ind.** *See page 119*

Thermoflex Insulation for Power Plants & Airframes. Illustrated folder 1N-136A. **Johns-Manville, Box 60, New York 16, N.Y.** *See page 11*

Miller Amplifiers. Technical Brochure. **Wm. Miller Instruments, Inc., 325 N. Halstead Ave., Pasadena 8, Calif.** *See page 79*

Test and Ground Handling Equipment. Brochure. **Pacific Airmotive Corp., 2940 North Hollywood Way, Burbank, Calif.** *See page 83*

Single-Row, Double-Row, and Rod-End Bearings. Catalog No. 54. **Shafer Bearing Div., Chain Belt Co., 801 Burlington Ave., Downers Grove, Ill.** *See page 81*

"Epon" Resin 828 and Curing Agent CL. Technical bulletin No. SC: 54-10. **Shell Chemical Corp., 380 Madison Ave., New York 17, N.Y.** *See page 87*

Torque Wrenches. Manual. **P. A. Sturtevant Co., Addison, Ill.** *See page 86*

"Truarc" Retaining Rings. Catalog No. AE-076. **Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N.Y.** *See page 129*